SCIENTIFIC AMERICAN SUPPLEMENT. No 1895

Entered at the Post Office of New York, N. Y., as Second Class Matter
Published weekly by Munn & Co., Inc., at 361 Broadway, New York
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXXIII., No. 1895.

NEW YORK, APRIL 27, 1912.

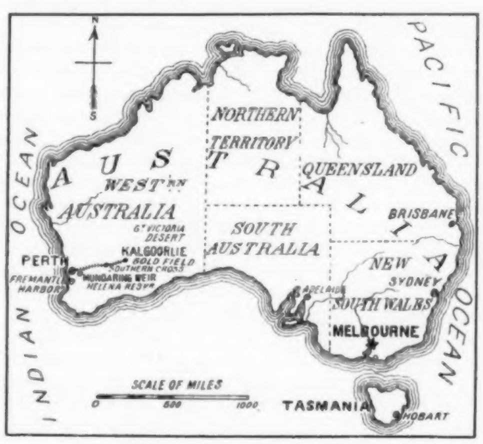
Scientific American Supplement $5 a year.
Scientific American and Supplement, $7 a year.

Water Supply for the West Australian Gold Fields

By L. E. Shapcott

The accompanying photograph represents the Mundaring Weir, or Helena Reservoir, probably the largest engineering enterprise ever undertaken in the infant State of Western Australia.

The Mundaring Weir, which has a water area of 16,000 square miles, the total length of which, from east to west, is approximately 380 miles, is the source of the Goldfields' water supply, located 351½ miles distant. A conception of this great work was originally projected in the early nineties by the then Premier of Western Australia, Sir John Forrest, in response to the stern necessities created by the discovery of gold in the arid regions of the State, and the subsequent rapid growth of the mines and townships inland. The design and execution of the work was entrusted to an eminent engineer, Mr. C. Y. O'Connor, who likewise designed the Fremantle Harbor Works, and who was then in the service of the State and labored to a successful conclusion, to the accompaniment of the persistent attacks of its opponents; the designing engineer, alas, only living sufficiently long to give the final directions for the completion of the Weir before passing into the Great Beyond. The scheme was opened on the 26th of January, 1903. Located some 36 miles from the coast, the water is pumped inland to the mines of Kalgoorlie and the boulder, supplying there in addition a population of 30,000 souls, and likewise feeding the towns and districts en route. A 30-inch main locking-bar steel conduit, which cost $9,000,000, and has a maximum delivery capacity of 5,000,000 gallons of water per diem, conveys the water from the reservoir to the various storage and distributing tanks, which range in capacity from a half to twelve million gallons. Eight water stations are provided to lift the water, which also gravitates a portion of the distance. The total net lift amounts to 1,210 feet, and under present working conditions, the water takes approximately four weeks' time to reach Kalgoorlie from the main reservoir. In regard to reticulation, the scheme now supplies 26 towns; the aggregate length of the mains now reaches 874 miles; there are 317 miles of reticulation to towns and mines; 90 miles of supply mains to towns; and 116 miles of agricultural extensions. The annual consumption of water from this scheme now reaches 1,058,931,000 gallons, with an average daily consumption of nearly 3,000,000 gallons. The Helena Reservoir has a capacity of 4,600,000,000 gallons, and altogether the total cost of the work amounts to £3,252,701. The working expenses, interest charges, and sinking fund contributions for the past financial year amounted to £263,-283, and the revenue was sufficient to pay working expenses, interest, and £63,744 toward the Sinking Fund, leaving a deficit of £25,615. Although from an American standpoint this may seem nothing remarkable in the way of achievement, yet Western Australia, with her handful of population, is justly proud of her Mundaring Weir and her Goldfields' Water Supply.



Map showing conduits from Mundaring to Kalgoorlie.

THE MUNDARING WEIR, WHICH SUPPLIES WATER TO THE KALGOORLIE GOLDFIELDS.

The Geology of Dam Trenches*

A Scientific Analysis of the Engineering Problems Involved

By Herbert Lapworth

The selection of an efficient economical site for a dam and the question of deciding when water-tight strata have been reached in the trench excavations form two of the most difficult problems with which the water engineer has to contend. The history of reservoir construction seems to show that experience alone does not always guard against failure, and probably also many instances of success must be attributed very largely to good fortune. A complete list of the reservoir failures in America would form a lengthy though exceedingly interesting document. In this country also our own reservoirs might be said to be capable of classification from the aspect of economy. Universally, however, as the result of experience in the early days of dam construction, there has been a movement in the direction of greater care, both in selecting reservoir sites and in trench work generally; but the difficulty of this class of work has not yet proved surmountable.

In reservoirs, as in other engineering works, each case has its own peculiarities; and for this reason it would be impossible to lay down rules, except on the very broadest lines. Hence, the matter of this paper must be largely in the nature of suggestion. There are, however, a few general principles that appear to be common to many dam trenches; and it seems to the author that the best method of dealing with the subject was to outline these principles, and to illustrate them where possible by actual reservoirs, mentioning the geological phenomena that have added to the cost or have contributed to the failure or success of the work.

The importance of selecting the best site that can be found can hardly be exaggerated, not only from the point of view of a possible failure, whether total or partial, of the work, but from the consideration of cost. Every yard added to the average depth of a trench may mean an expenditure of thousands of dollars, and consequently the careful selection of the best possible site may mean an enormous reduction in the cost of the work. There are probably instances where engineers, by careful thought and ingenious designing, have reduced the expenditure above ground by a substantial sum, and yet have spent ten times the same amount in trench work that might have been avoided had the center line been located a quarter of a mile up or down the valley. We have also the well-known instance of the Vyrnwy Dam, referred to later, where a saving of over one and one-quarter million dollars was effected by altering the site of the dam, a matter of only one-eighth of a mile.

PRELIMINARY INVESTIGATIONS AT DAM SITE.

Stratigraphy.—The site of the reservoir having been determined and the approximate position of the dam fixed, a contoured geological map of the dam site and the area for some distance above and below should be prepared. A mere inspection of the surface indications and a note of the geological beds or strata alone are not sufficient. The various beds should be plotted on a fairly large scale, not less than 1/2,500, so that the map shows the order and levels of the strata. The knowledge of the stratigraphy of a dam site is essential in determining the best position for the dam, for it enables us to determine the underground arrangements of the various kinds of rocks, and to ascertain whether there are any serious faults or disturbances in the area in question. It also helps us very often to comprehend the detailed arrangement of the beds in the trial shafts referred to later. Last, but not least, it tells us whether the area has been subjected to earth movements and the like, factors of almost as much importance as the nature of the rocks on the site. Many of the numerous dam failures on record might have been avoided, had a thorough knowledge of the stratigraphy of the site been obtained before commencing the work.

Trial Shafts and Borings.—No geologist would say that it is possible to prepare a detailed geological map of every dam site without considerable help from trial shafts or borings; in fact, the detail required for this kind of work renders the sinking of numerous shafts almost imperative. In many cases the ground may be covered with drift or scree, or the strata may be jumbled by surface-creep and the like. It becomes necessary, therefore, to seek for further information by means of trial shafts. Of equal importance is the information so obtained as to the jointing, faulting, and folding of the underlying beds when there are few rock exposures at the surface, the thickness of drift or superficial deposits, and the depth at which water-tight strata may be expected. The functions of these explorations should be not only to enable us to examine the rocks in various places in the area, but to interpret the stratigraphy of the site, and by these means to generalize on the condition of the site as a whole. They should be carried out in such a way as to demonstrate by means of the geological map the true geological structure.

In the author's opinion no expense should be spared in these initial explorations: an expenditure of several thousands of dollars is trivial in proportion to the saving that may be effected by such means. Every piece of information that can be secured before construction ought to be secured almost regardless of cost. It is an unjustifiable procedure to use the main trench as the principal means of investigation, and to incur heavy additional expense by adding wing trenches and the like, when possibly they might have been avoided had sufficient information been obtained in the first place. The explorations should not be restricted to the actual center line, but should be continued up and down the valley for some distance, so as to get the true geological structure and nature of the rocks over a considerable area. Especially also is it desirable to explore the hillsides thoroughly by deep shafts or by headings in order to make certain that water-tight ends may be secured.

Some engineers prefer bore-holes, but these are not nearly so satisfactory as trial shafts. They give practically no information as to the condition of the rocks themselves, unless a diamond drill is used; and here again only a small core is brought up. With shafts, on the other hand, a large surface of rock is exposed in the sides, which can be studied in detail. The shafts should not be less than 8 feet or 10 feet square, and in superficial deposits should be well timbered from the commencement. They should be sunk to considerable depths, occasionally well below what is considered will be the final depth of the trench, in order to make perfectly certain that the water-tight strata continues downward.

SINKING DAM TRENCHES.

The ideal dam is one which has the whole length of its foundations in water-tight rock with all percolating ground-water above the level of the foundations. The object of the trench, of course, is to sink below all loose, open, and unstable materials, these being:

1. Superficial deposits, such as alluvial and glacial beds of sand, gravel and clay.
2. Surface material broken up by weathering and surface movement.
3. Surface or subsurface material broken up by faults, folds and joints.
4. Subsurface material of a porous or water-bearing nature.
5. Subsurface material not sufficiently firm to take the weight of the overlying dam.

In England, dam foundations are sunk down to, and well into, the solid rock; invariably in the case of masonry dams, and generally in the case of earth embankments. In America, the rock bottom, as a rule, is regarded as ideal rather than essential. Many American masonry dams have been founded on the superficial deposits, with disastrous results; and in their earth embankments often no attempt has been made to penetrate below the first sound layer encountered.

SUPERFICIAL DEPOSITS.

The advantage of exhaustive initial investigations in superficial deposits is well brought out in the case of the Vyrnwy Dam. The late Mr. G. F. Deacon, in his preliminary survey of this valley, deduced from surface indications that the valley was the site of an old glacial lake, whose waters were at one time held up by a rock-barrier or rock-bar; and he placed the center line for the Parliamentary plans at the spot where he inferred the rock-bar lay. Before deciding on the final center line, however, he investigated the area within the "stony blueclay," lying about thirteen feet below the surface and extending for almost the whole width of the valley. Trial shafts and borings, however, showed that underneath this clay was an enormous mass of open gravel, highly charged with water, and acting as a channel for ground water flowing under the clay. It became absolutely necessary, therefore, to carry the puddle down to the rock for nearly the whole length of the embankment.

Again, in the Hury and Blackton reservoirs (Stockton and Middlesbrough water-works) patches of gravel underlie the boulder clay. It is, in fact, impossible to say in these circumstances when one may come across such materials, and whether they may not act as channels, bearing water from the reservoir under the embankment. The majority of the reservoir failures in America have been due to dam trenches being founded on superficial water-tight material, without ascertaining what lay below. The result has been, that when the reservoirs have been filled, or partly filled, leakage through porous beds under the foundations has undermined the structures, producing, in many cases, complete failure.

On the other hand, many of our British dams in the glacial deposits have been founded for parts of their length in the boulder clay, and have proved perfectly water-tight. The Font Dam of the Tynemouth Waterworks is an example of this construction.

It has been the general practice, where the depth of boulder clay is very great on the side slopes of the valley, to end the trench vertically against the clay. Both the Vyrnwy and the Upper Neuadd (Merthyr) masonry dams were continued in narrow trenches well into the boulder clay or drift, being founded on rock, but with their ends vertically abutting against the glacial material. In spite of these successes, however, the author is inclined to think that it is unwise to leave the solid rock bottom, unless it has been ascertained that no porous beds underlie the clay, or that the clay deposit is everywhere thick and continuous over the whole area of the reservoir site; that is to say, the preliminary investigation must have been sufficiently thorough to justify the step.

SOLID ROCKS.

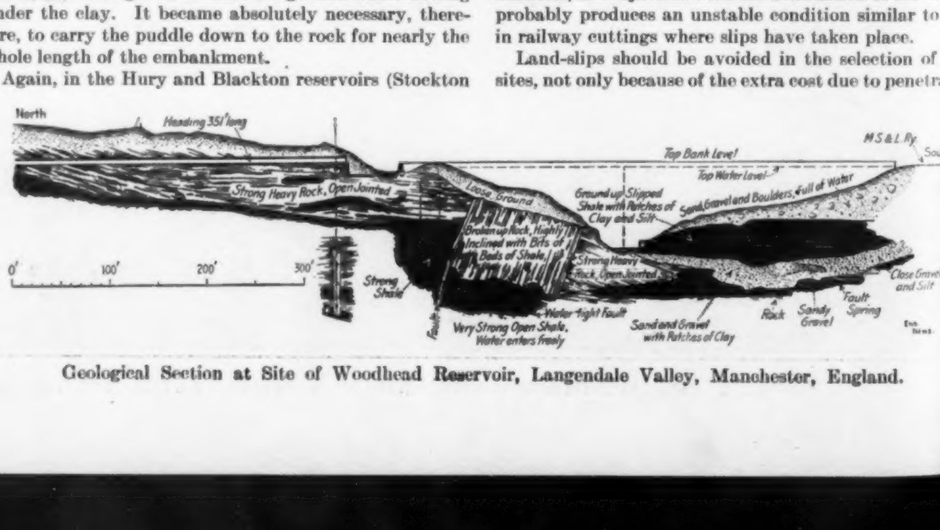
A.—Weathering and Surface Movement.—Overlying nearly all solid rocks there is soil, subsoil, and loose rock opened out and broken up by weathering and other agencies. These open materials of course, in dam trenches have to be penetrated because they are loose, unstable, and permeable by water. The depth of these open layers depends on many factors in addition to surface weathering, the most important being the natural jointing of the rock itself in the region, and the amount of folding, faulting, and other disturbing agencies at the dam site. The greater these disturbances the greater the depth of the open surface measures.

The principal factors producing broken-up surface materials, in addition to weathering agencies, are surface-creep and land-slips. A land-slip is generally assumed to take place suddenly; surface-creep is a very slow and gradual process. Land-slips are generally visible on the surface, though not always so. Surface-creep rarely, if ever, makes any sign on the surface. There are many areas of alternate shales and sandstones, such as the Yoredales and Coal Measures of the North of England, where it is rare to find that the rocks do not slope from one side to the other toward the valley. Under such conditions surface-creep is very common indeed; and it is, in fact, often difficult to say whether the disturbed ground is best described as surface-creep or land-slip.

The Leeshaw and Leeming Reservoirs (Bradford water-works) are both apparently in slidden ground of post-glacial age. This creep, due to the gradual movement of the beds at the surface down the slope, often causes the strata in the center of the valley to be buckled up and fractured; but this phenomenon is more frequently due to horizontal regional movement on a larger scale, as will be explained later.

In these shale and grit formations it is not always essential that the beds should slope toward the river for the phenomena of surface-creep and slipping to occur. Thus at the site of the Derwent Dam (Derwent Valley water-works) the beds are perfectly level on the west side, yet extensive slipping has taken place above the level of top water. The explanation of land-slips in level-bedded strata is not clearly understood; but the joining of the material, in conjuction with the denudation of the valley, probably produces an unstable condition similar to that in railway cuttings where slips have taken place.

Land-slips should be avoided in the selection of dam sites, not only because of the extra cost due to penetrating



Geological Section at Site of Woodhead Reservoir, Langendale Valley, Manchester, England.

* Condensed from a paper read before the Association of Water Engineers (Great Britain) in 1911, and published in the *Engineering News.*

the broken-up material before reaching solid rock beneath; but if there is a shaley rock-series, there is a possibility of the land-slip moving again after the reservoir is filled, owing to lubrication from the water in the reservoir. The Woodhead Dam of the Langendale reservoirs (Manchester water-works) is an example of a dam penetrating land-slips. The following is a description of the work:[1]

"The site of the (first or abandoned) embankment was at a narrow part of the valley, one side of which consisted of an ancient and extensive land-slip, which has pushed over the river and formed a steepy escapement of rock and shale on the other side. The valley itself . . . consists of the shales and beds of sandstone . . . called by geologists the Yoredale Rocks. . . . The puddle trench of the embankment was sunk to a considerable depth. . . . On the northerly or turnpike road side of the valley the puddle was tied into a thick bed of shale and then turned for some distance up the valley until the shale rose to above top water level. On the southerly or railway side the puddle trench was excavated for a considerable distance into the clay of the land-slip, and in the valley itself the trench was sunk to a depth of 17 feet below the river into what appeared to be sound ground. The character of the ground was supposed to be ascertained by careful boring before the work was commenced. The boring was . . . very deceptive, and the foundations did not prove to be what was anticipated. Great care was taken to secure the water-tightness of the reservoir, but when the reservoir was filled with water, leakage appeared, which was supposed to be the consequence either of water passing along the outside of the pipes or behind the puddle. Attempts were made to cure the leakage by sinking small cylinders to the pipes and pouring down fine ashes. This operation produced some good, and it was evident that the cause of the leakage had been rightly divined and was discovered; but as it still continued, notwithstanding all efforts to arrest it, it was finally decided to construct a new bank altogether. By careful boring, which occupied eight years, a place was at length discovered at which continuous shale existed right across the valley from top water on one side to top water on the other, and at this spot a new embankment has been formed. . . . The old bank was left in and the hollow between filled up."

[1] "History and Description of the Manchester Water-works," by J. F. La Trobe Bateman, F.R.S., p. 110 (1884).

The question whether leakage from a full reservoir, either under or around the trench, is serious or not, is one on which opinions differ among engineers of different countries. In America and India, for example, puddle trenches are not carried to such great depths as in Britain. Sometimes the puddle core is altogether omitted and leakage is expected, systems of drains being provided for carrying away the percolating water. The general opinion in these countries seems to be, that it is a waste of money to spend large sums in order to stop small leakages of water. So long as the leakage does not affect the stability of the embankment, or wash away the puddle in a clay trench, there is something to be said for this attitude; but the difficulty when dealing with an imperfect piece of trench during construction, always lies in deciding what is likely to be the amount of leakage when the full pressure of the reservoir comes upon the foundations. The catastrophes that occurred in the early days of reservoir construction in this country (England), though not affecting so much the question of selecting sites, have led British water engineers to aim at perfect water-tightness of the trench work, and the general practice is, if possible, to carry the work laterally and downward into retentive material. It has not always been possible to secure these ideal conditions, the extra cost involved in obtaining them having sometimes rendered such a course prohibitive, and the result has been considerable leakage, sometimes unforseen, sometimes expected, or even created by leading the water up from the foundations in vertical pipes. The leakage is allowed to escape into the river below the dam as compensation water, and care is taken to protect the puddle by means of concrete. This practice was adopted in the case of the Yarrow Dam of the Liverpool (Rivington) Water-works, where a strong spring was met with at a depth of about 150 feet below the surface, and since then, in many other trenches in this country.

Where the area of the leakage channels is small, or where the frictional resistance of the water-passages is sufficient to prevent high velocities, the tendency is for silting to take place, and for the leakage eventually to cease. This has occurred in innumerable instances in America, India, Britain, and elsewhere. An interesting example is mentioned by Mr. G. H. Hill of a reservoir 80 feet deep, in Yorkshire, where a leakage of 440,000 gallons a day took place through fine joints in the rock, but ceased entirely by the end of two years. On the other hand, there is a reservoir in this country, where the leakage through fissures in the rock has increased by five or six times within ten years, probably through the washing out of the fissures. The danger of leakage through fissure rock, where not led in prepared channels, lies in its tendency to undermine the embankment or to attack the puddle. Finally, it must not be forgotten that there are instances of dams, where the leakage through fissures in the rock was so excessive, that the reservoirs were not capable of being filled.

Grouting, or forcing cement grout under pressure, is sometimes recommended as a means of stopping leakage from a reservoir through jointed or fissured rocks. While this may reduce the amount of leakage, it is, in the author's opinion, scarcely ever likely to be successful in stopping the flow, except by an extraordinary chance. Reservoirs that have leaked through open joints have, however, been successfully treated by adding wing or arm-trenches, or by subsequent covering of the water-bearing outcrop with a layer of either puddle or concrete. This last method has been successful in stream courses in the Edinburgh district in preventing water percolating into adjacent mines.

A Curve Which Trisects Any Angle

A Modern Solution of a Classical Problem

By L. L. Thurstone

THE famous problem of trisecting an angle is known to almost every student of geometry. Most students have at some time or other exercised their ingenuity on this problem and the writer at one time also gave it some serious speculation, but of course his attempts to solve it within the restrictions of Euclidean Geometry were unsuccessful. In these attempts I designed a curve of very simple geometrical construction by the aid of which any angle could be trisected by a direct course. The curve and its equation may interest some of the readers of the SCIENTIFIC AMERICAN SUPPLEMENT and I am therefore appending a brief description of it.

In trisecting any angle we may follow two courses. We may draw an arc across the angle at random and then proceed to find a chord of the proper length to trisect the arc. Or we may decide upon a chord length, say 2 inches, and proceed to determine what radius of arc must be used to make this chord length the *exact* trisecting chord.

The curve here discussed was constructed on the latter principle. We assume a length of chord "a" (see figure) and by means of the curve we determine what radius will make the length "a" the trisecting chord.

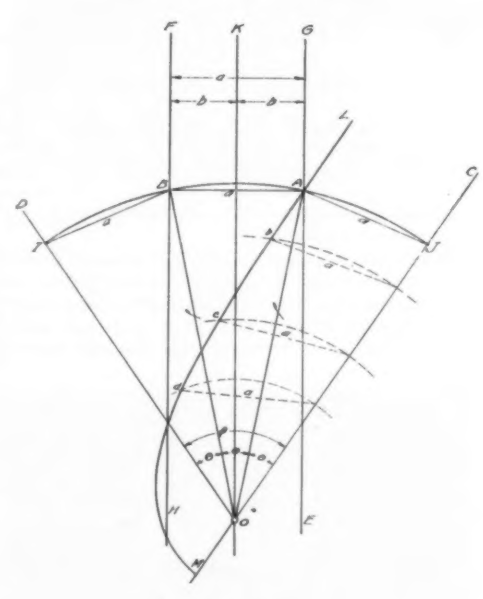
Let the angle to be trisected be denoted by φ and the arbitrarily chosen chord length by "a". Draw the bisector OK of φ. It is evident that the central angle subtended by a will decrease as the radius increases. The problem consists in determining the radius which will make a subtend a central angle $\theta = \frac{1}{3}\varphi$.

From the sketch it will be seen that the central chord AB will always be perpendicular to and bisected by the bisector OK of the angle φ. Hence, the locus of the extremities of the central chord will be two parallel lines FH and GE parallel to OK and distant $a/2$ from it. Similarly the locus of the extremity J of the chord AJ will be in the leg OC of the angle φ and the locus of I will be the leg OD of φ. The locus of the extremity A of AJ must be such a curve that if from any point in it an arc be drawn to OC with O as a center, the chord AJ is constant in length, equal to a. Now it will be seen that the intersection of the two loci GE and LM at A determines the proper radius ρ for the angle chosen.

The actual form of the curve varies with the chord length a chosen. The character of the curve is better defined by its equation which in polar co-ordinates with O as origin and OC as reference line is:

$$\rho = \frac{b}{\sin\frac{\theta}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The equation of the locus GAE in rectangular co-



CURVE TRISECTING ANY ANGLE

ordinates with origin also at O and OC as axis of abscissæ, is

$$\frac{y}{x - \dfrac{b}{\sin\frac{\varphi}{2}}} = \tan\frac{\varphi}{2} \quad \ldots\ldots\ldots\ldots (2)$$

By transforming equation (2) to polar co-ordinates and eliminating the common constants ρ and b we have a trigonometrical relation between the angles φ and θ. This relation, being satisfied by substituting 3θ for φ, proves the relation between θ and φ to be as 1 : 3, thus:

Transforming (2) into polar co-ordinates we have

$$\frac{\rho \sin\theta}{\rho\cos\theta - \dfrac{a}{2\sin\frac{\varphi}{2}}} = \tan\frac{\varphi}{2} \quad \ldots\ldots\ldots (3)$$

whence:

$$\rho = \frac{a}{2\left(\sin\frac{\varphi}{2}\cos\theta - \cos\frac{\varphi}{2}\sin\theta\right)} \quad \ldots\ldots (4)$$

Equating the values of ρ as obtained from equations (1) and (4) we have:

$$\frac{b}{\sin\frac{\varphi}{2}\cos\theta - \cos\frac{\varphi}{2}\sin\theta} = \frac{b}{\sin\frac{\theta}{2}} \quad \ldots\ldots (5)$$

and canceling constant b from both members:

$$\sin\frac{\varphi}{2}\cos\theta - \cos\frac{\varphi}{2}\sin\theta = \sin\frac{\theta}{2} \quad \ldots\ldots (6)$$

Rewriting to avoid fractional angles in the notation:

$$\sin\varphi\cos 2\theta - \cos\varphi\sin 2\theta = \sin\theta \quad \ldots\ldots (7)$$

From this we have:

$$\sin(\varphi - 2\theta) = \sin\theta$$

and

$$\varphi - 2\theta = \theta$$

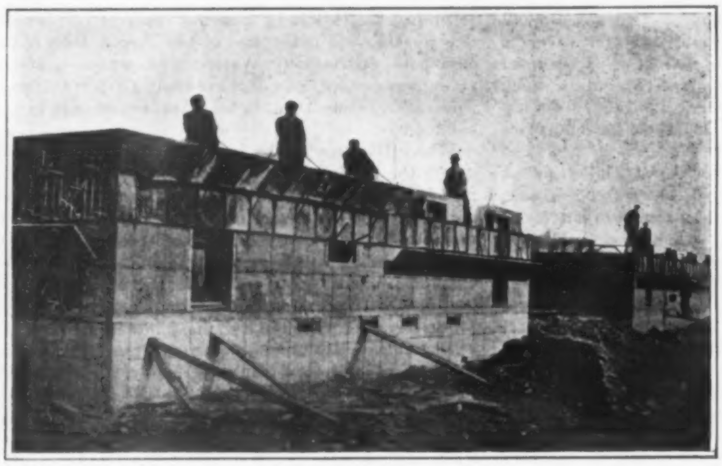
$$\text{or} \quad \varphi = 3\theta \qquad \text{Q. E. D.}$$

The method of constructing the curve may be carried out very simply as follows:

Draw any straight line as MOC in the figure and select a center O at random. Draw a number of arcs of different radii, each arc intersecting the line OC as shown by the dotted outlines. Now select the constant length "a" also at random. This will be the fixed trisecting chord length for which the curve is to be constructed. Having determined on a suitable length for "a," proceed to lay it off on each of the short arcs, from the intersection of the arc with the line OC. The locus of the other end of the chord "a" is the curve LM, obtained by drawing a smooth curve through the points A, b, c, d, etc.

If a French curve be designed in the manner indicated above, or the curve in the accompanying diagram copied, one is enabled to trisect graphically any angle by simply applying the curve with its reference line coinciding with one of the legs of the angle and its origin in the vertex of the angle. The intersection of the curve with the straight line EG, drawn parallel to the bisector and $a/2$ distant from it, is a point in one of the trisectors of the angle. After one of the trisectors is thus determined it is a simple matter to draw the other one symmetrical with it, on the other side of the bisector, completely trisecting the angle.

Gold Lacquer for Metals.—One hundred and twenty parts orange shellac, 30 parts gum mastic, 60 parts gum sandarac, and 30 parts Venice turpentine are dissolved in 750 parts of 90 per cent alcohol. After solution and precipitation, the solution is filtered and 25 parts picric acid, 10 parts dragon's blood and 5 parts boracic acid added to it.—*Deutsche Maler-Ztg.*



Swinging Up the Steel Frames.

The Pouring Operation in Progress.

A City of Poured Houses

Model Dwellings for Wage Earners

In a previous issue of the Scientific American mention was made of a new system of building, invented by a Washington architect, Milton Dana Morrill.

As this system has now been used on many buildings, including "the concrete city" at Nanticoke, Pa., it is probable that a further detailed description will be of interest to our readers.

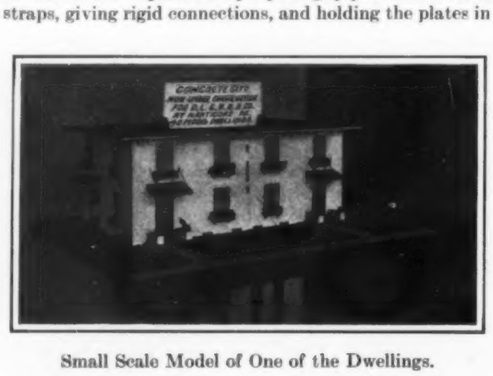
Model of the Concrete City.—The Houses are Built Around a Garden and Playground.

At Nanticoke, Pa., near the great mines of the Delaware, Lackawana and Western Railroad Company is now building one of the most interesting groups of buildings of the age. This a model concrete city for the wage earner. With a view to giving better housing conditions to the employees of this great company, Mr. E. N. Loomis, president of the Delaware, Lackawana Railroad Coal Company conceived the idea of building these houses of reinforced concrete throughout, which would not only furnish the operatives with model sanitary homes, but would serve as a demonstration of the possibilities in building industrial communities by this new process of pouring in steel forms, which is the invention of the architect, who is also the designer of this interesting group of buildings.

The forty houses are grouped in pairs, inclosing a park or play ground which is 300 by 600 feet. The group will be completed in the spring of 1912, work having been suspended during the cold winter months. This new idea in both design and construction has been worked out to bring the construction of the substantial fire-proof home within the reach of the wage earner. It is interesting to know that for the construction, products which have been heretofore considered as waste have been utilized. The buildings are of a mixture of coal cinders, sand and cement, poured into steel forms, which are set up forming the walls, partitions, floors and roofs.

While the idea of the poured house is similar to that which Mr. Edison predicted would supplant other modes of construction, the method is entirely different from the plan upon which he has been working. The steel forms here used have been developed and the practicability demonstrated in the building of a cement city, Virginia Highlands, near Washington, where many of these houses have been constructed, and the practicability of the plan has been conclusively proved.

Flanged plates are pressed into 24-inch square sections which are securely assembled by wedge connections, forming troughs around walls and partitions, the sides of which are separated by spacing pipes and slotted straps, giving rigid connections, and holding the plates in line. Only two tiers of these plates are used, as the lower tier is swung up by an ingenious system of arms, the whole being supported by concrete already built. After the inner and outer plates have been swung into position, forming a trough on top, this is spouted full and allowed to harden, the lower tier is then loosened and swung, and the process continued. By this means throughout the construction of the walls, the plates are not disconnected, but swung up one over the other until the roof is reached. The same forms are used for the construction of floors and roofs which are also of reinforced concrete. While all the buildings of this group are of similar design, the steel forms are arranged with variable corner sections which permits the construction of walls and buildings of almost any design and dimension.



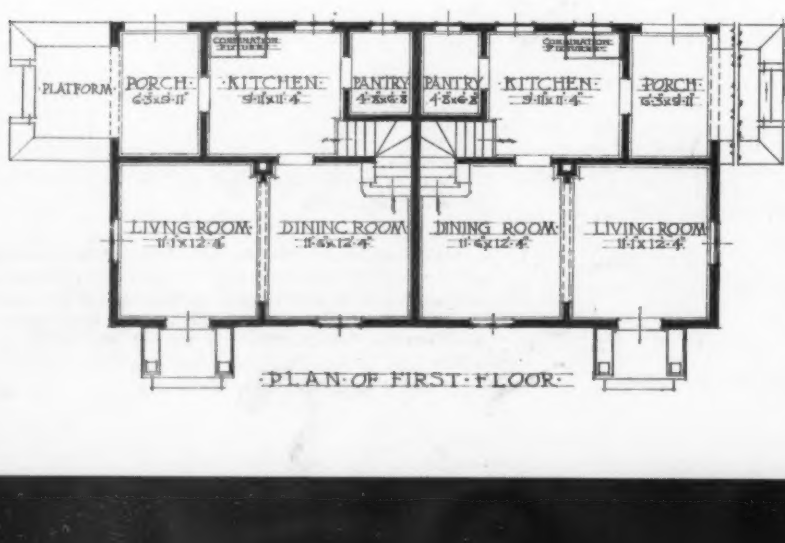
Small Scale Model of One of the Dwellings.

A novel system of building has been adopted in this group of houses. A railroad track is laid around the entire group and a mixing plant is mounted upon a flat car with elevator for hoisting concrete attached. Cars of sand, cement and cinders are attached to the mixing car, the concrete is hoisted from the mixer to an elevated hopper from which spouts conduct the mixture into the steel forms at the various parts of the building.

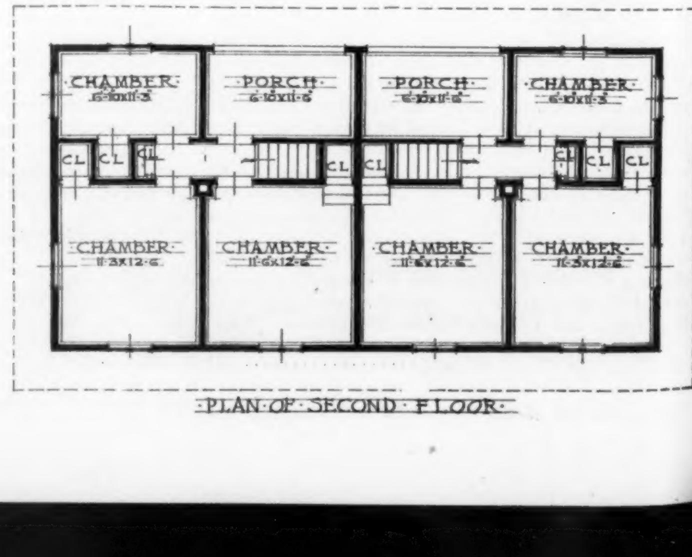
After a section of one house has been completed the mixing train is moved to the next and the process continued. The whole system is surprisingly simple and free from complicated mechanism. Hydrate of lime is added to the concrete for density and to weather-proof the mixture.

While this system has been in use somewhat less than two years it has been adopted for several other important undertakings. The demand for better and more substantial homes adjoining our cities has opened a wide field for the use of cement, and the increased land values and immediate demand for these new type homes, here built, furnish a valuable asset to land development, as has been shown at Virginia Highlands near Washington, where this system was first developed.

A second cement city development is well under way at High Lake, a suburb of Chicago, where the real estate firm, E. A. Cummings Company, report a remarkable speed of construction by this system, as well as unusual saving in cost. Here the entire concrete work, including cellar walls and first story walls of one of the bungalows, some 30 by 40 feet, has been poured in four day's time, and the coast of construction of 6-inch walls, which is ample for a one or two-story building, has been brought down to 8 cents per square foot, which is less than in the construction of frame houses. The houses have proved dry, and exceptionally warm during the past cold weather.



PLAN OF FIRST FLOOR



PLAN OF SECOND FLOOR

Shrine of Nyakang at Fenikang, with Five Tukls.

Dwelling of Shilluk King, Fashoda.

The Divine Kings of the Shilluk

Oslerizing Among the African Natives

Some time ago we described in the pages of the Scientific American the remarkable work that is being accomplished in the Lower Soudan by the Wellcome Tropical Research Laboratories, which has become one of the most important and interesting branches of the Gordon Memorial College at Khartoum. In addition to carrying out highly valuable researches in connection with the many tropical diseases incidental to Central Africa, the results of which have extended our knowledge of these maladies, their characteristics and alleviation, the laboratories are also contributing material of far-reaching importance upon ethnographical science. The interior of Africa is peopled by many strange tribes which are scarcely known to us, while their customs, origin, method of living and so forth are in many ways mysterious. The laboratories have dispatched numerous expeditions into the interior of the country in co-operation with the Government, and the complete character of their investigations is reflected very convincingly in the bulky reports dealing with the work of the laboratories.

One of the most interesting of these expeditions was that carried out by Dr. C. G. Seligmann. He penetrated the Shilluk country on the northern edge of the Bahr-El-Ghazel province. The Shilluk country is a narrow strip of land along the banks of the Nile between Kaka and Bake No, and Kodok and Taufikia. It is practically a grass covered country so that cattle-raising constitutes the staple industry. The population is estimated at about 40,000.

The nation traces its origin to the semi-divine hero, Nyakang, who with a small band of followers broke away from another tribe, and settled in this country. Nyakang was the first king of the Shilluk, and his origin is quite in keeping with the traditional mythology of such native tribes.

The villages for the most part are small, comprising only a few houses. Each Shilluk householder occupies a small group of two or three, and sometimes four huts, inclosed by a fence of dura stalks. One hut or *tukl* comprises the sleeping compartment for the householder and his wife, another is used as a kitchen, while the remaining dwellings serve as apartments for the children and servants, respectively.

The most striking feature is the veneration paid to the king, and the marked line of demarcation between the aristocracy and the commoners. The former is constituted entirely of the royal family—children, grandchildren and great-grand-children of the king. Royal descent however is not recognized beyond the fourth generation. Polygamy is practised, and the king has a large number of wives. In fact the greater number of the *tukl* in Fashoda are the residences of the king's consorts. The sons likewise take many wives, but the daughters must remain unmarried for the reason that it is unfitting for a king's daughter to marry a commoner, while at the same time she cannot marry a son as that would be incest.

The king is regarded with awe by his people and they pay him considerable honor. In the olden days he was not permitted to sally forth to battle. He maintains much pomp and ceremony, and is always accompanied by a bodyguard. In former times his word was absolute law and even to-day one and all bow to his decisions.

Paintings on Tukl of Nyakang at Fenikang.

The difference between the aristocracy and the commoners is exemplified in a still more striking manner. All the commoners of both sexes have their lower central incisors knocked out, and even the grandchildren may conform to this practice if they please.

Though the people honor the king in his prime, when he attains senescence they promptly prepare for his successor. The sovereign is killed with due ceremony at the first signs of ill-health or old age. Precisely what takes place on this occasion Dr. Seligmann was unable to ascertain, as the ceremony is associated with considerable folk-lore. According to this interpretation any son has the right to attempt to dispatch his father, and if successful to reign in his stead. The deed is carried out at night because then the king is alone in his inclosure with his wives, and without the bodyguard which attends his movements during the day. The fight that ensues between the king and his assassin under such circumstances must be of a desperate character, inasmuch as it is said to be a point of honor with the king never to raise an alarm. Other accounts narrate that the king is strangled by his wives, that the chiefs of the villages warn him in due course of his approaching end, and so on. It is very evident however that until about five generations ago the king was taken to a specially built *tukl* with a marriageable virgin and the two were walled in the building without food, fire, or water to die from starvation and suffocation, but this terrible ceremony has been abandoned.

The Shilluk people believe that Nyakang himself never died but simply disappeared. To them he is almost a deity, owing to his relationship with Ju-ok, the high-god of the Shilluk, who made man and is responsible for the order of things: who is invisible and fo mless, but like the air everywhere at one and the same time. He is above Nyakang and all other men, but only believed to be approachable through Nyakang and consequently the prayers and sacrifices to the high-god are conducted through Nyakang. The result is that a number of shrines have been raised to Nyakang throughout the country. In all he has ten graves. This is not very remarkable, for the later Shilluk kings also have had shrines erected to them, although it is well known that no one is buried in them.

The huts within the royal grave inclosure are generally more neatly thatched than the ordinary *tukl*, and the fence surrounding them is kept in a specially good state of repair. These dwellings, with the surrounding inclosed ground, are sacred, and no one except one or two aged people of either sex who are held responsible for the cleanliness of the buildings, is permitted to approach or enter them without due reason. Sometimes only a solitary *tukl* will be found to be inclosed in its dura fence, but as a rule there are three or four huts fenced off, one being over the grave of the king, while the others are occupied by those who attend to the maintenance of his shrine.

Owing to the significance of Nyakang, the fact that through him the Supreme Being Jo-uk must be invoked, the actual working religion is a cult of Nyakang. Each succeeding king receives the spirit of Nyakang, because it is transmitted in the process of killing off the reigning monarch when ill or old. Natural death must not ensue, as a calamity would befall the cattle, the crops, and even the human population. Similarly every precaution must

Shrine of Yur Adodit—New Tukl Being Built.

Part of Shrine of Nyakang at Fenikang.

be taken to prevent the sovereign dying accidentally.

Although Nyakang has ten tombs, the most celebrated are two in number, being at Akurwa, and Fenikang, respectively. At the latter, which is shown in our illustration, there are five huts. The old men and women who tend the shrines are supposed to be the descendants of the companions of Nyakang when he entered the country, and founded the kingdom of Shilluk. The old men act as priests, killing the animals brought as sacrifices, sharing their flesh, keeping the skins for themselves, and subsequently throwing the bones of the sacrifice into the river. The tomb is always invested with certain articles such as sacred spears, which are supposed to have been those originally used by Nyakang and his companions, although it is admitted that the original weapons were carried off by raiding dervishes during he times of the Mahdi. These spears are apt to accumulate through successive presentations and at intervals the older ones are withdrawn and presented to the most important men in the village. They are used for the purpose of killing the sacrificial beasts.

At Fenikang shrine one of the *tukl* is, in a special sense, the house of Nyakang, because his spirit is thought to inhabit it. The tomb is distinguished by a number of paintings very roughly executed on the outer wall. Dr. Seligmann remarks in his paper contributed to the Fourth Report of the Wellcome Tropical Research Laboratories whence this information and the illustrations are reproduced by his courtesy, that rectangular black areas relieved with white spots are not uncommon on shrines, but this is the only one which he has seen whose walls were decorated extensively or had drawings which could be recognized as represen ing animals. One of these strange designs is reproduced herewith. The paintings do not appear to convey any particular significance so far as the investigator was able to ascertain from his inquiries. Before the door of the *tukl* on which these paintings are displayed were a number of elephant tusks, the broad ends of which were thrust into the ground, while skins were spread on the floor of the *tukl* as if for Nyakang to rest thereon. The quaint ornaments forming the crowns of the roofs of these *tukl* (as seen in the photographs) are formed of a spear thrust through an ostrich egg and appear to be common to these shrines to Nyakang. Fenikang is stated to have been a village actually founded by the semi-divine hero and to have been his home for some time, the name itself in fact being a corruption of *fa Nyakang*, signifying "The place of Nyakang;" hence the extreme sanctity for this shrine.

The shrines of Nyakang figure in two of the most important tribal ceremonies—the prayer for rain and the harvest festival, respectively. A cow and a bullock are given to Nyakang in the rain ceremony, the bullock being killed while the cow is added to the herd belonging to the shrine. Both the animals are presented by the ruling king who participates in the ceremony at the Fashoda shrine. The bullock is slain by one of the guardians or priests before the shrine with one of the sacred spears, the king standing near the beast and shouting for rain to Nyakang, meanwhile holding a spear pointing upward before him. As much blood as possible is collected in a gourd and thrown into the river, while the same is done with the bones after the meat has been eaten by the guardians of the shrine, the skin being made into a mat for the tomb of Nyakang. In the harvest festival everyone brings some ears of ripening dura and thrusts them into the thatch of certain of the *tukl*. This is ground and made into porridge with water brought from the river. Some is poured out at the threshold of the hut specially reserved for Nyakang, and some on the ground within the hut, the outside of which is also anointed with the mixture. Until this thank offering has been made no one may eat of the new crop.

Another curious feature is the reverence extended to trees growing near the shrines of dead kings. In a way this is not remarkable seeing that the country is practically bare of trees, so that wherever they do occur in, or on the outskirts of, a village, the shaded ground beneath becomes to some extent a meeting and squatting place. In some cases where a tree has sprung up within a short distance of a shrine after the king was buried, it is generally believed that the tree has sprung from one of the logs lining the deceased sovereign's grave, so that the connection between the dead king and the tree readily suggests itself.

The dead kings may assume the form of several animals, and Dr. Seligmann relates an interesting anecdote in this connection. Yur Adodit, for instance, always takes the form of an insect called akwan. While the doctor was making inquiries near the grave of this king which was being built, an insect settled on his camera. He was about to examine it when he was requested by the chief with whom he was conversing not to touch it. The chief, his face showing the greatest pleasure, picked up the insect reverentially, carried it to the shrine only the base of which had been completed, and deposited it on a leafy branch which was thrust into the ground in the center of the shrine, that is over the grave of this particular king. The chief told the doctor that the appearance of Yur Adodit in his animal form showed that the dead king was favorably disposed towards the Doctor, and was not displeased at the inquiries he was making concerning the shrine. After this incident Dr. Seligmann found it appreciably easier to glean the information he desired from the chief and his people.

Monoplane Failures*

M. Blériot's Report to the French Government, which has Caused the War Minister to Suspend the Use of Monoplanes in the Army

Below we give a translation of the text of what is perhaps one of the most important documents dealing with the technical side of aviation that has yet been prepared. It is the communication of M. Blériot to the French Government, which resulted in the issue by the French War Minister of that startling order to suspend the use of monoplanes in the French army, which was only made known in the daily press this week. That it should have been written by the pioneer designer of monoplanes and should form such a frank and lucid *exposé* of a hitherto unsuspected weakness in such machines, is the finest possible vindication of the Etablissement Blériot as a scientific concern. It would be difficult indeed to over-estimate the importance of M. Blériot's conclusions, and no reader of his argument but will extend the greater appreciation to the author in that he of all those who have tackled the problem should have been the first to present what would seem to be the true solution.

True or not, however, the fact remains that the French army are having all their monoplanes re-trussed above the wings to resist the top loading that M. Blériot describes in his report, and it follows as a natural consequence that no designer can henceforth regard it as proper to suppose that the upper guys have only to support the dead weight of the wings. Likewise it follows that all monoplane users will proceed forthwith to have their wings re-trussed accordingly.

M. BLÉRIOT'S REPORT.

The death of Lieut. Sevelle was not, as have been so many preceding calamities, useless to the cause of aviation. It has brought to light a new conception of the forces to which aeroplanes are subjected in flight. It has come to explain the series of mysterious accidents that have overtaken Chavez, Blanchard, Lantheaume and Ducourneau.

Up to the present no one has admitted that the wings of monoplanes can carry top-loading. After Chavez's death, witnesses affirmed to having seen the wings fold *down beneath* the machine. No one heeded their words, regarding them as the outcome of an optical illusion; meanwhile the wings (of monoplanes) were strengthened once more. Then came Blanchard's death, followed by a second reinforcement of the wing-spars. Following upon that came the death of Lantheaume, which caused a military commission to decide that the wing spars should be strengthened yet a third time, and it was with these newly reinforced wings that Lieut. Sevelle met his death.

Alas, it was not the weakness of the wings that caused these accidents. These four deaths occurred under similar circumstances; the machines had remained for a long time in the air amid most violent *remous*. Chavez had crossed the Alps. Blanchard had journeyed from Orleans to Paris. Lantheaume had just finished a flight of 50 kilometers, and Sevelle a flight of 2 hours 10 minutes duration. Their machines had resisted perfectly the buffeting of the wind, when suddenly, as they (the pilots) proceeded to descend by *vols planés*, the wings, which carry very little positive loading at this time, broke and doubled up.

I do not speak of Lieut. Ducourneau's accident, for that constitutes the first occasion on which the upper guys were broken, and is probably due to an analogus cause.

In Lieut. Sevelle's machine the four upper guys were completely cut through.

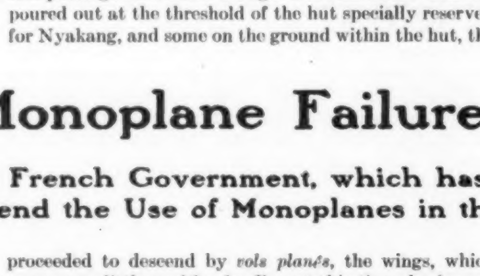


Diagram of Natural Descent and Forced *vol piqué*.

All these accidents having resulted in the same conditions led to the idea that the wings must be forced from above, and had to resist pressure acting vertically in a downward direction.

Then it was that I realized how the momentum of an aeroplane flying in a straight line, and made suddenly to descend by a *vol piqué*, would *reverse* the loading on the wing, and now this phenomenon cannot be doubted by any who care to analyze the problem.

A machine moving horizontally will, when the motive power is diminished, descend by a parabolic path, which will be longer in proportion to the initial speed. If, by a strong movement of the elevator, the pilot transforms the trajectory into a straight line slanting at a steeper angle toward the earth than the parabola, the machine is immediately subjected to a force from above. In order that it (the machine) should make this descent to earth, which takes place more rapidly than that resulting from the gravitational influence of its own weight, a *downward* force must act upon the wings.

The diagram herewith shows that, if the pilot is moving horizontally in the direction *AB*, and at the point *B* throttles his engine without touching his elevator, he will follow a natural parabolic trajectory, *BC*.

If, on the contrary, at the point *B* he suddenly uses his elevator in order to descend in the direction *BS*, of which the slope is greater than its small angle of incidence, it is evident that, in order to overcome the momentum of his machine, he must apply a force on the *top* of the wings, and at the same time of course this will stress the upper guys.

It is then the change from the direction *AB* to the direction *BS* that causes the danger to the pilot and not the *vol piqué* itself, which if performed slowly and progressively presents no objections.

There is no longer room for doubt that the deaths of Chavez, Blanchard, and Lantheaume were caused, not, as has been believed up to the present, by the breaking of the wings, that have withstood their trials and tests of *positive* loading successfully, but by the failure of the upper-guys, which have no strength to resist these forces coming from above.

It is therefore necessary to test monoplanes with a top loading on the wings, so as to obtain a system of upper bracing that will be of corresponding strength to the lower bracing now in use.

It is to be regretted that four deaths should have been required to pave the way to this solution, which must completely modify the design of aeroplanes.

What shall be the new factor of safety for these new forces? We estimate that, theoretically, the resistance of the upper guys may be less than the under guys.

In practice, allowing for the rare occasions on which the upper guys are stressed, we can allow, for a factor of safety of five with the lower guys, a factor of safety of three for the upper system.

This relationship of momentum and live-load on the machine also causes the factors of safety to change according to the speed of flight.

In effect, the kinetic energy is proportional to the square of the speed; consequently, if we allow a factor of safety of 5 for a machine incapable of exceeding a speed of 100 kilometers per hour, it is necessary to give a factor of safety four times as great, viz., 20, for the guys of a machine flying at 200 kilometers per hour. This explains how it is that accidents have not happened to machines that have much smaller factors of safety, but do not exceed 60 kilometers per hour.

In the matter of momentum, it would seem that a machine capable of 60 kilometers per hour and having a factor of safety of 3.6 will be as strong as a machine flying at 100 kilometers per hour with a factor of safety of 10.

Again, it is necessary to inquire if the pilot's own body can resist the sudden shocks that are the immediate outcome of those factors, and I feel certain that a man seated cannot resist a shock directed from beneath upward of a magnitude greater than twice his own weight without being immediately upset; and it is probable that he cannot resist a vertical upward force exceeding that which will stress the wings of his machine to a factor of 5 or 6, without serious inconvenience to his internal organs.

It is, then, necessary not to fall into the error of exaggeration in respect to these factors. Their proportion must be subordinate to the physical resistance of the pilots, who withstand, by shock on their bodies, the momentum effect, which is proportional to the altitude.

(This is only meant to apply to rigid machines like those in actual use.)

These new conceptions must sensibly modify the conditions of the acceptance of flying machines and will tend considerably towards safety.

*Reproduced from *Flight*.

The Balanced Aquarium*

Scientific Methods of Work for the Amateur Zoologist

By Raymond C. Osburn, Assistant Director of the New York Aquarium

The small aquarium as an object of interest and decoration in the house has become so common that its presence no longer attracts special comment. The custom of keeping such aquaria is, however, of comparatively recent origin. Goldfishes have been kept and bred by the Chinese and other oriental peoples for several centuries, though, to be sure, this was mostly done in small out-door pools in the gardens.

The balanced aquarium has been clearly defined by Mr. Henry D. Butler, in a book entitled "The Family Aquarium" (New York, 1858), in the following terms: "The aquarium is a receptacle for aquatic animal and vegetable life in fresh or salt water, which need never be changed. The old-fashioned fish globes were not aquaria in the proper sense, because it was absolutely necessary to change the water in them pretty frequently, lest the fish die. The vitalization of the water without this change comprehends the leading principle of the aquarium." Undoubtedly the failure to grasp the principle of proper balance was the special factor which prevented the small aquarium from becoming popular at a much earlier period.

The facts that animals require oxygen in respiration and that green plants give off oxygen in excess was discovered and published as early as 1778, but lovers of aquatic life were slow to apply this knowledge. In fact it was not until 1850 that the first properly balanced aquarium was described by Mr. Robert Warrington of Manchester, England, in a paper presented before the Chemical Society and entitled "On the Adjustments of the Relations Between the Animal and Vegetable Kingdoms, by which the Vital Functions of both are Permanently Maintained." Warrington found that goldfishes could be maintained indefinitely in a glass jar in which was placed some *Vallisneria* (tape grass) to supply the oxygen and with the addition of a few pond snails to clean up decayed vegetation. Further experiments were then conducted by him along similar lines upon marine animals and plants, and published in the *Annals of Natural History* for November, 1853.

The work of Mr. Philip Henry Gosse was also of the greatest importance in developing the balanced aquarium, and his book, "The Aquarium, an Unveiling of the Wonders of the Deep Sea," published in 1854, showed how rapid the advancement in the study of the marine aquarium had been.

In England and Germany the small balanced aquarium soon became popular in the home. In America little attention has been paid to it, although a certain few enthusiastic lovers of aquatic life have maintained aquaria with great success from the time the principle first became known. Mr. William Emerson Damon in his book, "Ocean Wonders," gives to Miss Elizabeth E. Damon of Windsor, Vermont, the credit of being the first person in the United States to keep a properly balanced aquarium, the receptacle being a two-quart jar supplied with fishes, tadpoles and pondweeds (*Potamogeton*).

The idea is prevalent, born of the old days of fish globes and persisting through ignorance like many other exploded notions, that the aquarium requires a vast amount of time and fussing and especially that the more frequently the water is changed, the better it will be for the animal life. Nothing could be farther from the truth, for when a balance is secured the less changing of anything the better it will be, for fear of disturbing the nice adjustment which Nature has set up and *the water should not be changed at all*. Yet anyone maintaining a balanced aquarium will agree that the question first and most frequently asked is "how often do you have to change the water?" The writer has known persons who for years had kept aquaria equipped with plants and animals for proper balance, who still thought it necessary to change daily all or part of the water in order to maintain the animal life.

The writer well recalls his own early attempts as a child to keep small native fishes in an aquarium made of a cast-off wash-boiler partially sunk in the ground in the garden, and the ingenuity with which he rigged a small tube to the pump-spout by the horse trough so that when anyone pumped water a small portion would escape for the benefit of the fishes. A few water weeds would have done the work of aeration more successfully and with much less trouble; but the knowledge of the proper method was lacking, and after a number of abortive attempts the experiment was given up in despair. I have no doubt that thousands of persons have had similar experiences with various kinds of fish globes and other improper aquarium apparatus.

Another prevailing notion is, that the small aquarium is simply a plaything serving to amuse the children or to afford an outlet for the energies of an occasional crank; and its only other excuse for existence is found in the fact that the green plants and goldfishes make a bright spot in the room. Even if this were all, who will deny that its existence is justified? But excuses are not necessary. Let it serve for the one as a plaything or bright spot in the room, but for the person who cares to study the life in the aquarium—and there is a constantly increasing number—the aquarium becomes a piece of scientific apparatus from which can be learned many of Nature's laws that regulate the outside world.

The unbalanced fish globe with its occasional renewal of water is unnatural, as unnatural as the attempt of a person to live in a closet by opening the door once a day, filling the space with fresh air, then shutting off all ventilation until the next day. The cases, as far as respiration is concerned, are exactly parallel. It is possible to supply oxygen to fishes in the small aquarium by means of apparatus which will pump the air into the water, but this again only meets the problem half way. It supplies the oxygen, but does not remove the carbon dioxide which can escape only by passing into the air at the surface of the water.

The balance of plant and animal life means complete and continual ventilation. Not only is oxygen supplied in sufficient quantities by the plants, but the carbon dioxide given off by the animals in respiration is consumed by the plants in the process of starch making. The adjustment is Nature's own and all animals are adapted to it. Such an arrangement is a pond in miniature and may be used in the scientific study of aquatic life of various kinds. In the majority of cases, to be sure, only goldfishes are kept, in addition to a tadpole or a few snails and plants.

According to the interests of the aquarist, however, this may be varied indefinitely. Various other attractive exotic fishes of striking colors, forms and habits may be readily secured from dealers, or the collector may take up the study of local native fishes, the natural history of which will be found no less interesting than that of the exotic species.

Aquatic insects afford a most interesting and almost infinitely varied field for study, and their habits, metamorphoses, etc., may be most readily investigated by this means. Again, if the aquarist is interested in aquatic botany, he will find here excellent opportunities and means for studying many water plants. Marine life is even more varied than that of the fresh water, and endless opportunities are afforded to those who live within reach of the sea. The microscopist will also find a constantly changing and ever interesting field of research in the minute life of the aquarium.

As an adjunct to the scientific laboratory, the aquarium has become a necessity. Here it may vary in size from the common finger-bowl for minute animals to tanks for the larger forms. The various aquatic laboratories such as those at Woods Hole, Massachusetts, and at Naples in Italy, to cite two of the best known, make constant use of aquaria and could scarcely exist without them. Nearly all colleges and universities have some means of maintaining aquaria, usually of the balanced sort, while a few, such as Trinity College, and Pennsylvania and Princeton Universities even possess facilities for the storage and circulation of sea water in larger tanks.

Naturally, larger aquaria have the advantage of supporting a larger and more varied stock, but it should be borne in mind that for scientific as well as for other purposes, the proper adjustment is of far greater value than mere space or variety of life. In the high-school, grade-school and even in the kindergarten, balanced aquaria have found a place where they encourage nature study among the children. The New York Aquarium has equipped hundreds of these for various schools in New York city.

THE MEANING OF BALANCE.

The factors which govern life in the balanced aquarium are the same as those which obtain elsewhere in nature, with the important difference that certain of them are under control. In fact we may consider the aquarium as a miniature pond in which the conditions of food, temperature and aeration are under the control of the operator. In the natural pond the variations of temperature alone are sufficient to produce important cycles in the balance and in the life of the organisms.

To secure and maintain a balance in the indoor aquarium is the most important problem which confronts the amateur aquarist. Temperature, which is such an important factor in the natural pond, can easily be controlled indoors within the limits which are likely to affect seriously the inhabitants of the aquarium. Similarly the light factor offers but little difficulty and food can easily be added in the necessary quantities.

The problem of aeration is more difficult. In the natural pond, with its large surface ruffled by the breeze, this takes care of itself, as a sufficient amount of oxygen can be absorbed from the air to supply all the animals that can find food within its waters; but in the narrow limits of the aquarium, with its restricted surface, comparatively greater depth, and the absence of any agitation of the water, the absorption of oxygen at the surface does not take place with sufficient rapidity to sustain much animal life.

To supplement the surface absorption of oxygen, it is necessary to grow plants in the aquarium. It is a well known fact that in manufacturing their own food from simple substances, plants give off oxygen as a waste product. This process takes place in the chlorophyll, or green matter of the plant, and in the submerged plants of the aquarium the oxygen passes off directly by absorption into the water. The fishes are thus supplied with oxygen given off by the plants as waste substance.

Having absorbed the oxygen, the fishes combine it with the carbon of the food to obtain energy, and, in the process of respiration, give off to the water quantities of carbon dioxide or carbonic acid gas as a waste substance. This gas, composed of carbon and oxygen, is absorbed by the plants and the carbon used in the process of starch making, while the oxygen is returned to the water again as a waste substance. Thus the animals and the plants of the aquarium are mutually benefitted, each supplying something that is required in the life processes of the other.

Plants, however, are able to manufacture starch, and consequently absorb carbon dioxide and release oxygen, only when they are exposed to sunlight. It follows then that on dark days the plants have less capacity for aeration than on bright days, and that they yield more oxygen in sunny windows than in dark corners. Moreover they can make starch and consume carbon dioxide and yield oxygen, only during the daytime. Further than this, they consume a small amount of oxygen in their own respiration both day and night, so that at times when they are not engaged in starch making they tend to consume a part of the oxygen of the aquarium, although they use only a small portion of that thrown off during the day. If the water of the standing aquarium is supplied with an excess of oxygen during the day, a considerable amount of the oxygen will remain in solution in the water and aid in proper aeration throughout the night.

It is evident then that an aquarium well stocked with plants will support a larger quantity of animal life during the day and in bright weather than it will at night or on dark days. The animal life of the standing aquarium must therefore be regulated to meet the poorest rather than the best conditions of oxygen production by the plant life.

Temperature also affects the rate of starch making and consequently of oxygen elimination, as the protoplasm of the plant is more active in a higher than in a lower temperature. However, the fishes are also less active in colder water and consume less oxygen, so that these factors balance each other and temperature does not especially affect the aeration of the aquarium.

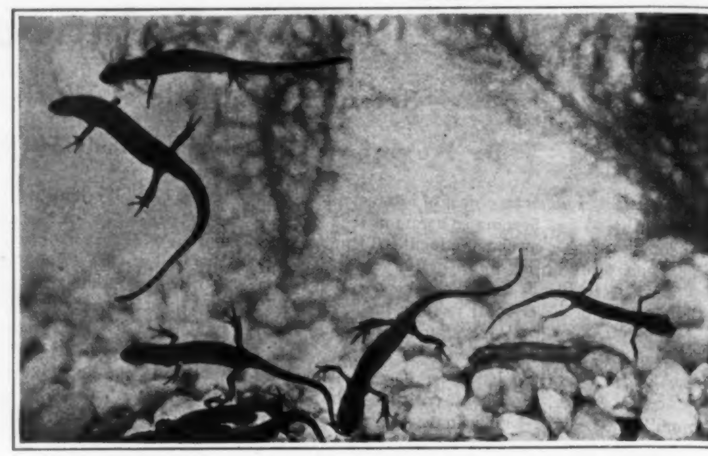
THE AQUARIUM TANK.

Undoubtedly the best kind of a receptacle for the beginner is the oblong, straight-sided aquarium with metal frame, glass side and slate bottom. The medium size, holding six or eight gallons, will be the best for the beginner. The smaller sizes are difficult to balance and the larger ones are more expensive. For larger aquaria, eight gallons and upward, it is the only type that can be used to advantage. When well set up such a tank will last for years without leaking, and is easily reset, or can often be readily mended by running a little asphaltum or an aquarium cement in the joints. The rectangular, straight-sided, all-glass jars are excellent; better in some respects than those with metal frames, for they are not likely to spring a leak.

The glass jars, however, are more likely to crack and so prove an extra expense, but in the hands of the experienced aquarist they are perhaps the most satisfactory for sizes under five gallons. Care should be taken to see that such jars rest firmly and evenly upon their bases, and that they are not subjected to sudden changes of temperature. The cylindrical jar with straight vertical sides is satisfactory to maintain, but the inmates appear somewhat distorted through the curved sides. For smaller aquaria the ordinary battery jar is as good as anything, except for the distortion, and has the advantage of being cheap. Very beautiful and well balanced aquaria can often be made with the two-quart size, but these are suitable only for very small animals and few of them.

To test the limits of the capacity of the two-quart size, the writer once kept in such a jar, with plenty of weeds and in good light, a carp nearly as long as the diameter of

Young Geographic Turtles.—These Should be Provided with a Float on Which to Climb Out of the Water.



Common Newt.—Very Abundant and Well Adapted to the Balanced Aquarium.

the vessel. The fish continued to live in good condition for several weeks until the experiment was accidentally brought to an abrupt end.

On no account should the ordinary globes be used. They are often sold because of their cheapness, but they give the specimens a very badly distorted appearance, and what is much worst the constricted top affords but a small surface area for exchange of gases with the air and makes it almost impossible to clean the jar properly. The slight additional cost in securing the proper sort of tank will be repaid many times in the satisfaction with which it may be managed.

PLACING THE AQUARIUM.

The aquarium jar or tank should be placed on a firm base where it will not be subjected to much vibration and where it will not have to be moved frequently. Fishes are sensitive to vibration in the water and jarring or moving the aquarium frightens and disturbs the inhabitants. It should not be placed too near a radiator, and if it is near a window it should be carefully guarded from draughts in cold weather. North windows are the most suitable, since sufficient light is afforded for the growth of the plants and the direct rays of the sun, which tend to heat up the water and to over-stimulate the plant growth, will be avoided. If a south exposure is necessary, the tank may be placed farther from the window or it may be shaded from the strong sunlight by a small screen of cheesecloth stretched upon a light frame.

PLANTING THE AQUARIUM.

This is an important proceeding, as upon the successful establishment of the plant growth depends the aeration of the standing aquarium and consequently the health of the animals. Many kinds of aquatic plants, both wild and cultivated, will grow readily in the narrow limits of the aquarium. The best species are those that will live entirely submerged and which have (1) narrow, ribbon-like or (2) finely divided leaves.

In the first class are the tape-grass (*Vallisneria*), arrow-head (*Sagittaria*) and pond-weed (*Potamogeton*); and of the second class, fanwort (*Cabomba*), milfoil (*Myriophyllum*), hornwort (*Ceratophyllum*) and waterweed (*Anacharis*). Two or three of these plants placed together in the tank give a little diversity and make it more attractive than will a single species. Fine gravel or coarse sand or a mixture of these should be placed in the bottom of the aquarium to the depth of one or two inches, depending upon the size of the aquarium.

The plants can be anchored by packing their roots in the sand or gravel, and if necessary large pebbles can be placed about the bases of the plants until they become firmly rooted, or the lower ends of the stems may be weighted by wrapping with a small piece of soft lead just above the roots. Some aquarists insist that a layer of soil should first be placed under the gravel, but in completely aquatic plants this is quite unnecessary, while the soil is often a source of danger to the animal life through the decomposition of its organic ingredients.

Nearly all of these plants will slip readily and the slips will soon form their own roots if anchored to the bottom by a pebble or a strip of lead. The tape-grass sends out runners, from the joints of which young shoots arise.

To obtain the best results, the aquarium should be planted at least a few days before the animals are introduced. This allows the plants a better opportunity for taking hold of the sand and it also permits them to thoroughly aerate the water in preparation for the animal life.

The plants must of course be provided with a sufficient amount of light or they will not grow, as they are able to manufacture their food only in the presence of sunlight. For reasons stated elsewhere the north window affords the best light for the aquarium. If the plants grow too luxuriantly they can readily be trimmed. Some aquarists prefer to trim off all the parts that come to the surface, thus keeping the plants entirely submerged. There is no doubt that such a method affords the maximum of aeration, since the more the plants are submerged, the less is the opportunity afforded for the escape of oxygen at the surface.

However, many persons prefer the appearance of some plants floating at the surface, and there can be no objection to this so long as there is a sufficient amount submerged. Perhaps the most picturesque, and therefore the most satisfactory, results for the average person are obtained by providing at least two kinds of plants, one like the arrow-head or pond-weed with broad leaves which are allowed to float at the surface, and the other with finely divided leaves (milfoil, fanwort, etc.) kept submerged by trimming. The little duckweed (*Lemna* sp.) which floats entirely at the surface with its tiny roots hanging straight down in the water for a short distance, makes an attractive addition.

The plants available for aquarium purposes are entirely too numerous to mention here. There are many native species, some of which can be secured in nearly every pond and stream. They are generally annuals and do not live indefinitely, and the most satisfactory ones are those handled by the dealers, since these are cultivated especially for the purpose. These for the most part have been introduced from the tropics where they flourish perennially.

STOCKING THE AQUARIUM.

The experienced aquarist will naturally know what he wishes and how to secure it. The beginner, in his first efforts to keep an aquarium, should start as simply as possible with only the commoner and hardier fishes and wait until he has proved successful with these before attempting to handle rare or expensive stock. Carps and the ordinary goldfishes known as commons are undoubtedly the best for the beginner within easy reach of a dealer. The highly bred, fancy varieties of goldfishes are less hardy and the same is generally true of the exotic fishes, however attractive they may be. Almost any of the native fishes may be kept easily and will prove interesting and attractive.

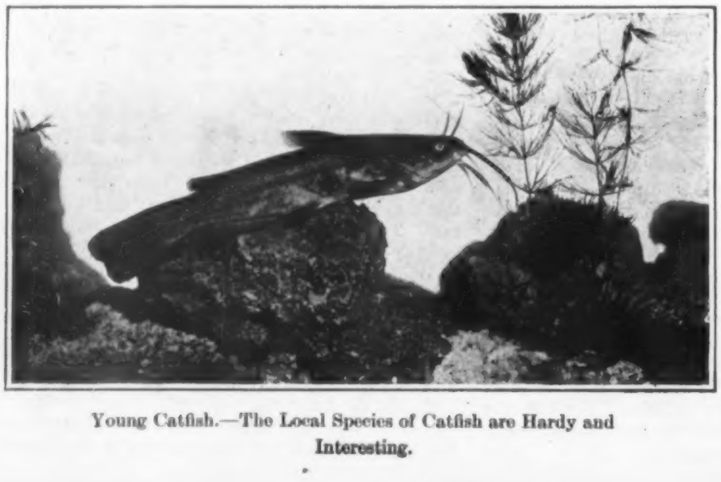
Catfishes are perhaps the most hardy, but the various suckers and minnows, as well as young sunfishes, basses, etc., can readily be kept. These can be collected with the aid of a small dip net, and the study of the local species should be much more common than is the case. Why so many people are satisfied to keep ordinary goldfishes when there are so many native fishes of more lively habits and graceful form, is only to be explanied by the fact that they give so little trouble and can be bought of a dealer instead of collected at a brook. Of course one can readily understand the attitude of the fish fancier who makes a specialty of breeding the various strains of goldfishes or of keeping rare exotic forms of bizarre appearance or unusual habits.

One serious error into which the beginner is likely to fall is that of overstocking. In his enthusiasm for the fishes and his love for their attractive colors and movements, he places more specimens in his tank than can be readily provided with oxygen. Often, when they are not all affected in a short time, the result may be that they are gradually enervated until the loss of some of them establishes a proper balance of the animal and vegetable life. Until the management of the aquarium is thoroughly mastered, the rule should be to keep well under the limit of animal life.

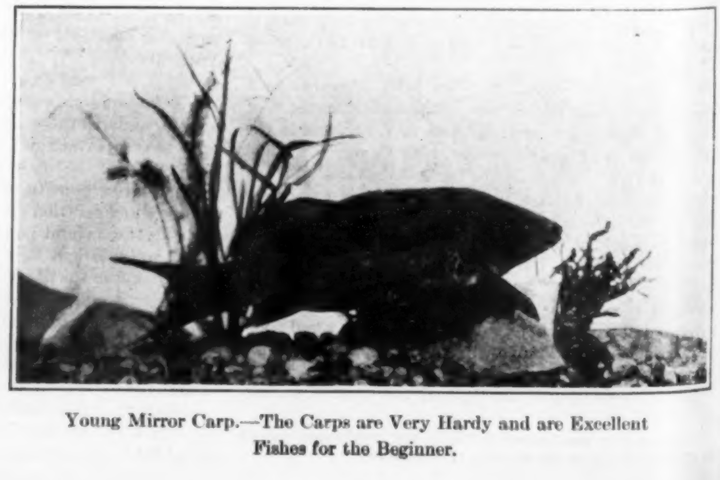
It is difficult to lay down any hard and fast rule for this, because the number of fishes that can be kept depends upon their size and kind as well as upon the proportions of the tank and the amount of plant life in good thrifty condition. It may be stated that the beginner will do well to supply only a couple of fishes three or four inches long to an aquarium of five or six gallons of water when the plants are in good condition. When he is well enough acquainted with the habits and appearance of his fishes, he will be able to know at once when his tanks are overstocked before any losses take place.

There are, of course, many sorts of animals besides fishes that are adapted to aquarium life. The tadpoles, larvæ of frogs and toads, are easily collected in any pond, or some of them may be purchased from dealers. In addition to their interesting habits they are useful scavengers, but unless they are large it will not do to introduce them into the aquarium with carnivorous fishes. In early spring the eggs may be collected and reared. Those of the frogs are laid in gelatinous masses, those of the toad in long strings.

Of the numerous salamanders, the pale axolotl and the common mud-puppy (*Necturus*) both of which have external gills, are easily kept. The most attractive of the salamanders is the common or spotted water newt (*Die-*



Young Catfish.—The Local Species of Catfish are Hardy and Interesting.



Young Mirror Carp.—The Carps are Very Hardy and are Excellent Fishes for the Beginner.

Young Tautog.—A Very Hardy and Interesting Fish for the Marine Aquarium.

Young Long-Eared Sunfish.—Small specimens make Attractive Pets and are Easily Kept.

mictylus viridescens). These beautiful and graceful little animals, although without gills, live well in the aquarium, since they are able to absorb sufficient oxygen through the skin, or may occasionally rise to the surface and fill the sack-like lungs with air. They swim readily with the limbs folded against the sides, or they climb with ease among the vegetation. They are carnivorous and are best fed on mealworms and pieces of earthworms. The eggs of the mud-puppy can often be obtained in large masses in ponds in early spring, and the larvæ may be reared as easily as those of the frog, but the eggs of the newt are laid singly among water plants.

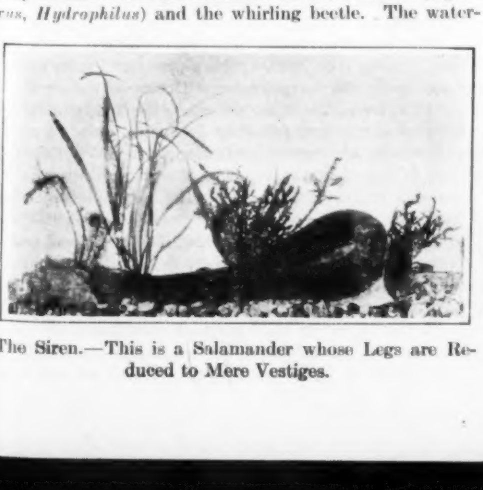
Young turtles are interesting, but the most of them are better adapted to terraria than to the ordinary aquarium as they need to have some way of climbing out of the water. The softshell or freshwater leather turtle is more aquatic than other species and does not need to climb out, but must have loose sand in which it occasionally buries itself. It is carnivorous and feeds well on earthworms, mealworms and pieces of fresh meat.

Young alligators are frequently brought from Florida, but it should be made a punishable offense to do so, for sooner or later they die unless special care is taken to provide them with heat and sunlight. The New York Aquarium is the recipient annually of many of these little fellows, usually in an emaciated condition because they have not fed well, and many of them do not recover, even under the care of an expert aquarist. They should be considered strictly hothouse pets and handled accordingly.

The temperature of the ordinary living room in winter is too low for alligators as they require 80 degrees to 85 degrees for their best development and should not be allowed to drop below 75 degrees. Below this temperature they become sluggish and chilled and refuse to eat. If kept warm enough they will feed well on a varied meat diet consisting of fish, crayfish, earthworms, frogs, etc., alive or dead, or they will take fresh beef. The majority of the water turtles are also carnivorous and may be given the above mentioned food, but the diet should be studied, as the different species vary somewhat in this respect. The same conditions of temperature should be applied here as with the alligators.

The pond and river species of crayfishes are well suited to the small aquarium. Those from the mountain streams and cold springs are harder to keep on account of the difficulty of maintaining a sufficiently low temperature during the warm months. They should not be kept with fish smaller than themselves, for they sometimes make too good use of their large pincers. They should be provided with some sort of a retreat in the form of rockwork or stones under which they can hide part of the time on bright days, as they are more or less nocturnal in habit, some species will climb readily among the water weeds. They are naturally scavengers and will eat almost anything, but prefer a meat diet.

There are numerous aquatic insects which can readily be kept in the small aquarium and which offer a very attractive field for study. Of those available in the adult stage may be mentioned the hard-shelled water beetles (*Dytiscus*, *Hydrophilus*) and the whirling beetle. The water-bugs such as the oarsman and the electric-light bug (*Belostoma*) are among the commoner and larger of the true bugs. The larvæ of the dragon-flies, caddis-flies and the dobson or helgramite are even more interesting and may be kept until they emerge in the adult winged condition. These forms are chiefly carnivorous, and if kept together the smaller may disappear into the rapacious stomachs of the larger. The dragon-fly larvæ are even cannibalistic and unless provided with enough food the larger may devour the smaller, even of the same species. Any of the above forms may be readily collected with the aid of a small dip-net. While their study has been chiefly confined to the entomologist, they will amply repay the labors of the aquarist.



The Siren.—This is a Salamander whose Legs are Reduced to Mere Vestiges.

FEEDING.

In the selection of food, one must naturally be governed by the needs of his animals—some species are partly or entirely herbivorous while others are carnivorous. Practically all of our native fishes are carnivorous and thrive best upon a meat diet of some sort, while the goldfishes and carp are largely vegetarian in their diet. Prepared fish foods may be obtained from a dealer in aquarium supplies, and he may be consulted as to that best adapted to a particular species of fish. In the case of carnivorous fishes, the prepared dry food may be supplemented occasionally by the addition of mealworms or of earthworms cut into small pieces according to the size of the fish. Special care should be taken, however, that such animal food is removed if not eaten as it decays much more readily than vegetable matter and so causes greater danger of pollution.

To prevent the dry prepared food from becoming scattered over the surface of the aquarium, it is advisable to make use of a floating glass ring which can be secured from a dealer. This not only gives the surface of the aquarium a neater appearance after feeding time, but prevents the escape of smaller particles to contaminate the water. Care in the matter of feeding is of the utmost importance in preserving the balance of the aquarium and in keeping the animals in good condition. It must be remembered that the usual fault is that of overfeeding and the conditions should be studied carefully.

CLEANING THE AQUARIUM.

It must be clearly borne in mind that cleanliness is absolutely necessary to the welfare of the inhabitants of the aquarium. Contamination can arise only by bacterial decay of organic substances allowed to remain in the water. There are three general sources of such organic matter; *First*, fecal matter from the animals, relatively unimportant because the deposits are small in amount and regular in occurrence, *second*, decaying vegetable matter from dead portions of the plants, also relatively unimportant since in the well balanced aquarium there is little tendency for the death of the plant tissues, and *third*, decay of excess food matter, the usual source of pollution.

It is a common but very mistaken notion that an animal should have food at hand at all times to keep it in good condition. It is well known that various forms of domestic animals, as well as the wild species confined in zoological gardens, make the best growth and keep in the most satisfactory condition when supplied only with what food they will clean up at one feeding. This applies with equal force to the inhabitants of the aquarium, but besides there is a real and grave danger of contamination in supplying more food than will be readily consumed.

The first indication of serious pollution is a slight clouding of the water caused by the presence of countless millions of bacteria. This may go on until the water is of a milky color and the balance of the aquarium is completely upset by the accumulation of sulphur and ammonia compounds set free in the water by bacterial decomposition. How can the accumulation of dead matter be prevented? The usual means is to introduce some animal that will act as a scavenger to clean up refuse matter. The forms generally made use of are the tadpoles and fresh-water snails.

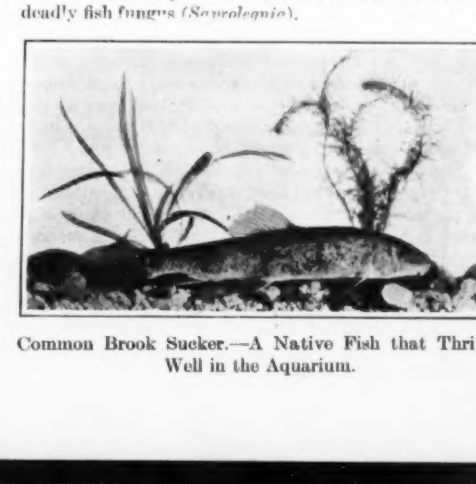
Either of these under ordinary circumstances wil clean up waste particles of food and decayed vegetation and work over the fecal matter of the fishes, and will also tend to prevent an excessive development of the microscopic plants which form a green scum on the glass. If larger portions of plants begin to deteriorate it will be found best to cut them off and remove them since if they are not in good condition they will not serve for aeration and will become a source of danger.

If care is taken in feeding—and a little study and experience in this matter is the only safe guide—no appreciable amount of food need be left to decay. If for any reason not all of the food is consumed or if there is any accumulation of fecal or other matter, these may be readily removed by means of a long pipette, or a rubber tube used as a siphon. For the small aquarium the pipette with an inside diameter of one-quarter inch and fitted with a large rubber bulb, is most convenient, or, the tube may be used without the bulb by placing the thumb over the upper end while introducing it and while withdrawing it after it is filled.

For larger aquaria the pipette is rather tedious and the siphon is recommended. In either case the water should be strained through a cheesecloth net and allowed to flow back into the tank rather than to add fresh water to replace it. As has been stated elsewhere, the less changing of the water the better, for fear of introducing some new factor to interfere with the adjustment already established. It will occasionally be necessary to add water to replace that which escapes by evaporation. This should be done a little at a time and care should be taken to have the temperature the same as that of the water in the tank.

For the purpose of removing any deposits on the glass of the aquarium, a swab can be made out of a stick with a bit of cheesecloth wrapped about the end. The cloth may be removed each time it is used, which should not be more often than is necessary to keep the glass reasonably clean, or if it is used over it should be carefully cleaned and sterilized each time in hot water. The swab will serve not only to remove ordinary dirt, but also the green scum of the minute plant life which in strong light will soon cover the glass. These minute plants do no harm—in fact they are as beneficial in yielding oxygen as are the larger ones—and they are a natural part of the balanced life of the aquarium. However one keeps an aquarium to enjoy the view of its miniature water world, and if the green scum interferes with the view it may be removed without detriment to the adjustment. The scum grows thickest on the side nearest the light and it may be allowed to develop on that side as it will serve to screen the strong light somewhat from the animals.

For removing inanimate objects from the aquarium or for readjusting them, a strong pair of wooden forceps is advisable. The hands should not be put into the water and on no account should the fishes be taken into the hands. If it becomes necessary to remove the fishes a small net of cheesecloth should be employed, and great care should be taken not to injure them by loosening their scales, as any such abrasion offers a foot-hold to the deadly fish fungus (*Saprolegnia*).



Common Brook Sucker.—A Native Fish that Thrives Well in the Aquarium.

MARINE AQUARIA.

As most of what has been said of the fresh water aquarium will apply with equal force to the salt water aquarium, a detailed account will not be necessary. The factors governing life are the same in both. The best plants for aerating are the species of green algæ known as sea-lettuce. The common broad-leaved form is usually best arranged by floating at the surface by a few small pieces of cork in such a manner that portions of the leaves will extend downward into the water. The species of marine plants are numerous and the various red, green and brown forms with strap-like or with finely divided fronds may be placed at the bottom to give variety and color, as well as to aid in aerating the water. Very often pebbles with these plants attached may be secured in shallow water.

Unfortunately the salt water aquarium is a practical impossibility for most persons who are unable to make occasional visits to the shore. Artificial sea water can be easily prepared at a trifling expense, if the formula of Gosse is followed: chloride of sodium (common table salt) eighty-one parts; chloride of potassium, two parts; chloride of magnesia, ten parts; sulphate of magnesia (Epsom salts) seven parts; total, 100 parts. A pound of this mixture is sufficient to make about three gallons of artificial sea water. It should be filtered before placing in the aquarium.

To be sure, natural sea water contains many other salts, but they have been found unnecessary for the animal life of the aquarium and may be neglected. The sea water part of the problem is thus readily solved, but very little marine life is ever handled by dealers in this country and the difficulty of obtaining animals and plant renders the salt-water aquarium impracticable for the person of average means who lives away from the sea.

To one who is within reach of the sea, however the marine aquarium offers a never ending and ever varied field for study and investigation. Animals and plants may be obtained the year round, and many of them live well within the restricted limits of the aquarium. The many species of hydroids and sea anemones, marine worms, bryozoans, mollusks of many kinds, crabs, shrimps and other crustaceans, sea squirts or ascidians, as well as fishes are to be obtained and give a variety to the miniature scene which cannot be paralleled in the fresh water aquarium.

Some of the small aquaria at the New York Aquarium have been maintained in a balanced condition for several years—one for as long as twelve years. Of course both animals and plants have been occasionally added to the stock, but the balance has not been interfered with during that time. Fresh water in small quantities must occasionally be added to the marine aquarium to replace that which evaporates. The addition of sea water would, in the course of time, cause the salinity to become too great, since the salts do not evaporate.

Special care should be taken, whenever any new animals are added, to observe that they do not die and upset the adjustment of the aquarium by their decomposition. Portions of plants which are deteriorating may be removed and fresh ones added. Practically all of the marine animals are carnivorous. They may be fed upon pieces of clam, oyster, or fish, cut to proper size or finely grated for the smaller animals.

Sea snails make good scavengers, but some of them are vegetarians and may attack the plant life too freely. However, these are just the points which the aquarist will be interested in determining for himself, and, with the proper attention, will offer no great difficulties. As in the fresh-water aquarium, it is very important not to overfeed and to remove by means of the siphon any excess food material which might by decaying interfere with the proper balance of life.*

* At the conclusion of this article, as originally published, a list of aquarium societies and a bibliography is given.

Fundamentals—I*

The Essential Principles of Engineering Practise

By Onward Bates, M. W. S. E.

I rashly accepted an invitation to address the Western Society of Engineers at this time, and before I had determined in my mind what I ought to say to you, was asked by your secretary to name my subject so that it could be announced in advance of the meeting. This inquiry put me in a quandary, for I had some rambling ideas which I thought would interest our members if I could collect and dress them with proper words. But it was difficult to find a title which would include the probable result of my efforts and cover many subjects, indifferently treated. It would not do to call it the "Engineers" pigeon hole of more or less relevant considerations," for that might create an impression of lightness or frivolity, and the title itself must have something attractive and suggestive about it—more important than the name of the writer. Engineers are interested in subjects and if the subject advertised does not strike their fancy they will not come to hear it discussed, no matter by whom the discussion is presented. So, following the example of distinguished public speakers, in the pulpit and out of it, a subject was sought which could not fail to interest you, and in looking for a starting point the word "*Fundamentals*" seemed to claim the distinction of being at the bottom of all engineering practice, for all of us are aware that a fundament is a foundation, and that the whole theory and practice of the profession is based on its foundations or fundamentals. It is a fortunate choice for me, since it permits me, in my arguments, to build any form of structure which rests upon a foundation, giving me great latitude in the presentation of the subject, and if, with this privilege, I am not able to lead your thoughts in stable and upright lines it will be clear that there is something wrong with my fundamentals.

In discussing engineering fundamentals it may be well to begin with the engineer and to consider what he is, where he came from, how he became an engineer, what he is here for and what is his ultimate purpose. In the first place, he is not fundamentally different from other people. He is, or ought to be a man, the best kind of a man. As to where he came from, it may be that he was born in Europe, Asia, Africa, the islands of the sea, or our own America. He does not come from any particular race or nation or family. He belongs to no particular class or grade of society, although none of us will accept him as a complete engineer if he is not a high-minded and estimable man. As to how he became an engineer, it is to be hoped that it was from his own choice, anticipating an honorable and interesting occupation, in the pursuit of which he would find satisfaction and enjoyment. To the choice of the profession must be added study and training in the schools of learning and of experience. He is here to do his duty and his ultimate destiny is that of all good men. He is born into the world just as other men are and he dies as others do, and his beginning and his end are probably the same as if he had followed some other profession. He is built from standard specifications and his physical and mental attributes are like those of all men. It is a mistake to think engineers are naturally different from the rest of humanity. An engineer may think himself to be a different and superior being when compared with those who are not engineers and in this belief lead a segregated existence, but he cannot maintain such a position by the theory of moments. There is no way by which we may escape the necessity of taking our places and doing our duty in the midst of a community of men.

Let us examine the engineer critically, sound him to bed rock, expose his fundamentals and see if he is molding his character and building his profession on a sufficient foundation.

Whenever a civil engineer makes a formal address to his fellows, he follows the practice of the surgeon who told his patient that an operation on him "was not really necessary, but then you know, it is customary," and proceeded to cut him open. I follow this time-honored practice and, as usual, quote Telford's famous definition, to wit: "The profession of a civil engineer, being the art of directing the great sources of power in nature for the use and convenience of man," etc. Thus we assume a sort of divine mission in this world. We become custodians of the forces of nature and guardians of the material interests of mankind. We speak of ourselves as the pioneers of civilization, and we claim that the glories of this twentieth century are due to our conserving care and our benevolent exploitation of nature's wealth, for which all men who are not engineers become our debtors. I remember at an annual banquet of this society when this country was rejoicing in accounts of the prowess of our arms in the Philippines and in Cuba, one of our distinguished members in a speech claimed with great and convincing eloquence that all of the credit of victories won was due to the engineers, and we engineers who were present acknowledged the fact with modest but tumultuous applause. Now this is all very good and most encouraging when indulged in among ourselves, but it might be disputed in an open forum and it is to be noted that in public the engineer stands serenely on his own dignity and does not demean himself by disputing the common people. We are notorious for our modesty and do not sing our own praise on the streets, although there are times and occasions when this actual or assumed modesty causes us to fail in securing justice for our profession and its members. Still there is to be found here and there in addresses and professional papers, an intimation that we who do so much and carry such great responsibilities for our fellow men are not properly appreciated and rewarded in proportion to our deserts. If it be true—and I fear it is at least partly true—that we put up a stiff front to the world and keep too much to ourselves, as if we were nursing a grievance, with the consolation that insofar as we are personally concerned, virtue is its own reward; then is not the attitude which we choose to take toward the world imitated in some degree toward members of our own profession? It is not possible for one engineer to be proficient in all branches of the science which are practiced at the present day. This leads to specializing, and one who practices a specialty is apt to overvalue that specialty and to undervalue the specialties which fully occupy the talents of other engineers. This leads again to the assumption of particular titles by the practitioners of specialties. There are a number of such titles which are warranted by general consent of the profession at large, among which are those pertaining to the four divisions represented by the National Societies. In addition, the number of titles assumed by individuals is constantly increasing. The list is already too large for me to attempt to enumerate, but I may mention as the last ones which have come to my notice in printed matter those of *Acoustical Engineer*, *Illuminating Engineer*, *Literary Engineer* and *Sales Engineer*. It really seems time for the regulation—if such a thing be possible—of the use of any engineering title; but it is not my present purpose to suggest any method of regulation. The variety of titles is quoted as evidence that the profession lacks coherence and that among its members there is the same tendency to segregation that is shown in our attitude toward other occupations.

Returning to my hypothesis that engineers are different or think themselves different from other men, the reason for this difference must be either in the natural make-up of men who elect to be engineers, or in their training and subsequent associations. My observation leads me to believe engineers to be naturally like other men and that the latter reason must prevail. It may be that an early mistake is made in assuming engineering to be an exact science and that this idea is so drilled into the engineering student that he can never be entirely free from it. It is common to speak of some boy as being fond of mathematics and that in consequence he will make a good engineer, and yet practicing engineers find their work hampered when their assistants place too much reliance on mathematics and other subjects taught them at school. It is true that the student cannot be too thoroughly instructed in the studies preparatory to practice, and the problem is how to acquire such knowledge and preserve it for use and at the same time to cultivate and develop the faculties of reason and judgment. As the engineer takes on years and advances in position, he deals more and more with problems which cannot be solved with mathematical accuracy and which are determined by reason and judgment and sometimes by conciliation and concessions. The factors of such problems must be ascertained as accurately as possible before what is called by the Supreme Court "The Rule of Reason" is applied. Computations must, of course, be mathematically correct, but these are so often based on variables or assumptions that reason must be applied in the mathematical operations, as well as in considering the results of them.

In the years of preparation for actual work those who are charged with the education of prospective engineers carry the responsibility of instructing them in the fundamentals, teaching them to reason, to discriminate, to judge, to decide, and to act.

Referring again to the famous definition of an engineer, "using the forces of nature for the benefit of man." We may construct our theory of the profession on this definition and still miss the fundamentals of it; that is, we may fall short in our estimate of nature, and of man, and erect a profession on insufficient foundation, failing to make full use of our opportunities. A study of this definition reveals the noble purpose of the engineer's profession. To direct the sources of power in nature requires some knowledge of the laws of nature. Nature's laws are established by God and are unchangeable and eternal. Not all of them are known and perhaps man may never learn them all. A law in general is "a rule of being or of conduct established by an authority able to enforce its will." It is also defined as "the mode or order according to which an agent or a

* Paper read before the Western Society of Engineers, and published in its Journal.

power acts." The power which makes a law, or a superior power, may annul or change it. Human laws are simply rules which may be good or bad, and are in effect only so long as the maker of them has the desire and power to enforce them. The engineer has to do with the laws of man in applying the laws of nature for the use and benefit of man. Hence the engineer must be a lawyer who can use both natural and human laws. In this capacity it seems most appropriate that while lawyers whose profession is to conduct lawsuits or to advise as to the prosecution or defense of lawsuits, or as to legal rights and obligations of parties are retained because they are versed in human law, engineers are called to act in cases to be decided in accordance with equity and justice. It is well known that the law of the land does not always secure equity and for this reason special courts of equity are established. Equity means "natural or right, the giving, or desiring to give, to each man his due, according to reason, and the law of God to man;" also "fairness in conflicting claims."

It will be seen from the above that the engineer practices and judges under the statutes of natural law and of human law. Natural law, as already stated, is the law of God and is immutable. A work constructed in conformity to natural law will stand. If natural law is violated, it is sure to fail. When we read of the failure of the Austin dam we know that fundamentals have been neglected, that natural law has been violated, and the result is the punishment for that violation. This does not imply any criticism upon those who built and cared for this dam, for they may have faithfully used their knowledge of natural law and yet the failure is unquestionably the result of a violation of some such law. Every movement and condition of matter in this universe is subject to the natural law of God, which unfailingly punishes those who neglect or violate it. On the other hand, human law is as fallible as human nature and is always subject to change by those who are vested with the power of law-making. It is based primarily on the moral law of God, but in its application frequently fails to give to each man his due, according to reason, and the law of God to man; that is to say, it is not always equitable. Experience teaches us that in the application of human law we are not always rewarded for obedience, neither are we always punished for violation, and our respect for such law diminishes in proportion as we observe its inefficiency.

Now if the engineer is to direct the forces of nature for the use and benefit of man, he must, to some extent at least, know the laws which control these forces. Here we find a noble theme, which I can barely mention without being overcome by the magnitude of the subject. The words "water," "air," and "electricity" cannot be used in this connection without bringing to mind the wonderful accomplishments of engineers who had some knowledge of natural laws and endeavored to employ that knowledge for the good of men. When a natural law is once known, the engineer may depend upon it absolutely, even to the extent of risking the life and welfare of himself and his fellow men.

I call to mind a famous controversy which seemed to hinge on the knowledge of a natural law. When James B. Eads built the jetties and opened the mouth of the Mississippi River to commerce, he did so in the face of great opposition from engineers and was violently opposed by many who were distinguished in the field of river hydraulics, and he only succeeded in obtaining from Congress the privilege of doing this great work on the condition that it should be at his own cost and risk, coupled with that of such friends as had faith to support him. He was not even allowed to choose that pass of the delta which was most suitable for his purpose, but was given the privilege of trying his experiment on another pass not so suitable and situated so that no harm would come if this so-called experiment proved a failure.

We all know the result—how eminently successful it was, and how the pass, which Eads asked for and which was the right one to improve by his method, has since been improved by the corps of Government engineers which had formerly fought his proposal so vigorously. Eads undertook this work and carried it out under great difficulty in obtaining funds for expenses and subject to all physical embarrassments which accompany any great engineering work. What was it that gave him this confidence and prompted him to risk his reputation and his fortune, and to labor for years to prove that he was right? It was because Eads was acquainted with a natural law, namely, that the amount of sediment carried in flowing water is proportional to the velocity of its flow; that as the velocity decreases, sediment is deposited and shoal water is made; as the velocity increases it picks up more sediment and carries it away, thus creating deeper water. By confining the flow of water in the south pass to a width limited by the jetties he constructed, the current was increased, the channel was deepened and for 20 years he maintained a channel, navigable for vessels drawing 30 feet. It was Eads' confident statement at the time of this controversy that he staked everything on the natural law of God, which brought this subject to my notice in an emphatic way and has ever since caused me to hold in reverence these natural laws.

An engineer who accepts in full Telford's definition of his profession cannot be a materialist. He comes into the study and knowledge and the application of both God's natural laws and God's laws requiring fairness and impartiality to men. It is not sufficient for him to have just enough knowledge of the law of gravitation to teach him to dam a stream and convert the weight of running water into power, and then to distribute the value of that power among men without regard to equity, caring only to escape penalties imposed by human law. If he is a reasoner—one who looks for fundamentals—he will realize that in directing the great sources of power in nature he is working in harmony with the Creator who is infinitely wise and just, and his character will be strengthened by the effort to increase his knowledge of these divine laws and to use that knowledge for the benefit of man on whom the Creator has bestowed this earth. Some knowledge of natural laws is possessed by the most ignorant of men who use this knowledge for their benefit.

Sir Isaac Newton knew very well that when the stem of an apple which supported it on the tree gave way the apple would fall to the ground. Any one who did not know that much would be considered a fool, and yet Sir Isaac will for all time be known as the seeker of fundamentals who inquired for himself why the apple fell and then discovered the natural law of gravitation. History informs us that it was men who looked deep into fundamental reasons who enriched the world with the benefits of science. The true scientist, whether he be an engineer or not, must search out the secrets of the Creator with reverence, and must feel himself spiritually enlightened as they are revealed to him.

Some time ago an eminent electrical engineer told me of sensations experienced by him in his work. I wish I could quote him at length, but I can only remember the statement that he was filled with awe at the wonders accomplished, and how this mysterious force could be controlled and utilized when so little is known of its source. It also brought him to the consideration of the temporality of human life when he reflected that the accidental touch of an electrically charged wire meant that in less than the twinkling of an eye he would, by this unseen power, be ushered into that world from which no engineer ever returns. Truly, the direction of the sources of power in nature is a task which should lead man to consider the fundamentals of life itself.

To be continued

Engineering Feats and Cheaper Food Supplies

The increasing exigency of the question of a plentiful food-supply for civilized nations, a question which has already led to serious political disturbances in the Old World, and which lies at the root of much recent legislation in our own country, makes it of prime importance to consider with scientific equitableness every possible method of cheapening the cost of provisions to the consumer.

Concerned in this cost are three factors, production, transportation, and distribution. With the last, which chiefly involves the moderate or excessive profits of the middleman, we do not wish to deal. It is our purpose to call attention to the enormous part played by the modern engineer in the first two factors, and to the hope held out for the future by even more daring projects than have yet been accomplished.

Our latter-day civilization, indeed, rests on that facility of traffic made possible by the network of railroads, tunnels, bridges and canals with which the engineer has girdled the globe, a system culminating in the stupendous achievement of the Panama Canal, soon to be thrown open to commerce.

But it is obvious that the most complete and elaborate development of systems of transportation will be of no avail for feeding the peoples of the world if production be inadequate. Since production depends on fertility of soil, amount of arable acreage, and labor, we have in these the ultimate elements of cheap or costly food.

And it is here that the engineer again comes to the rescue by plans for increasing the fertility of the soil, extending the area of tillable territory, and thereby attracting labor back to the land.

The immense success of irrigation in our Western States is too well known for comment, and now English engineers and economists are enthusiastically considering the possibility of rescuing the Sudan from centuries of aridity and making it once more a great granary. It is proposed to do this by utilizing the waters of the upper Nile, which could be done by the building of locks and dams at the third and fourth cataracts. Sir William Willcocks believes that the region between Atbara and Khartoum could be thus rendered as fertile and populous as of old, while incidentally protecting lower Egypt from recurrent flood and famine. The cost of irrigating the territory from Atbara to the Blue Nile would be about $50,000,000, but the land would be easily worth four times that sum.

Equally enthusiastic are French engineers over the merits of a plan for making the Sahara blossom like a rose by means of an artificial water connection with the Mediterranean. Without going into details we may say that skilled engineers consider the project entirely feasible, and matters have progressed so far that certain pessimists have raised the cry that this "destruction of the desert," and consequent interference with the currents of heated air ascending from it will most injuriously affect the climate of Western Europe.

Finally, an even more daring scheme is afoot in Russia for altering the flow of waters on so vast a scale that even meteorological and climatic conditions may be improved. Agricultural interests in the eastern and southern provinces suffer severely from the frequent droughts, which are ascribed partly to extensive deforestation and partly to the progressive drying out of Western Asia. The idea has been conceived, according to *Himmel und Erde*, of diverting the flow of certain Siberian rivers from the north to the south so that their waters would eventually find their way into those great inland seas, the Ural and the Caspian. Since the surface of these would be thereby doubled or even quadrupled there would be a great increase in the atmospheric moisture and consequent precipitation of the surrounding country, as well as larger available supplies for irrigation where desirable.

This diversion of flow is to be accomplished by building dams across the Obi and Tobol rivers at points where their banks are exceptionally high. When the water had reached the top of the banks it would stand at a far higher level than the Caspian, and considerably above the Ural. It would then only be necessary to cut a short canal through the divide which separates the northern-flowing from the southern-flowing rivers of Western Asia to direct the fructifying waters of these mighty streams towards the two great lakes instead of allowing them to be lost in the barren wastes of the Arctic Ocean.

An Alarm to Indicate the Approach of Icebergs

Ours is an age of unprecedented scientific and technical progress, and it has become something of a fixed habit to indulge in occasional self-congratulation in regard to the marvels of modern civilization. After such optimistic reflections, it comes as a very severe shock to our pride in modern attainments to find that, after all, even the most exquisitely equipped and ultra-modern engineering structure is exposed to dangers which may annihilate it even before it has fully started on its career of active service. It is true that the wireless system with which the "Titanic" was equipped served its function well, and was the means of saving those seven hundred odd lives that were preserved in the recent disaster. Yet all the wealth and luxury of modern improvements, with which this floating palace was equipped, were unavailing to save it from its terrible fate.

At such times it is only human to go through the usual steps of "locking the stable after the horse has gone," and reflect what might have been done to prevent the catastrophe. Nor are such reflections by any means useless, for upon them must be based our future efforts to prevent a repetition of the calamity. The question arises naturally, whether something might not be done, by means of some of the scientific instruments at our disposal, to give an alarm of the approach of an iceberg. An instrument of this kind has been devised and patented by W. H. Bristol, whose name is well known to engineers and industrial chemists as the maker of certain pyrometers for technical use.

The principle of the instrument is extremely simple. It consists of a thermo-element, whose two junctions are placed near one another, the one, however, being freely exposed to the temperature influences of the surroundings, while the other is inclosed in a heat-insulating cover. Hence, when the instrument is carried from point to point in a locality in which the temperature undergoes a sudden change, the exposed junction rapidly follows up the change in temperature, while the inclosed junction does so much more slowly, so that an e.m.f. is set up, which is employed through suitable relay mechanism to actuate an alarm.

Mr. Bristol suggests that the instrument might, among other things, be used for detecting the presence of an iceberg in the neighborhood of a ship, as the sudden fall of temperature on approaching the iceberg would cause the alarm to sound.

Whether such a thermojunction iceberg alarm will eventually prove successful in practical operation is a matter which can only be decided by actual experiment. But, with the recent catastrophy fresh in our minds, it is well worth noting Mr. Bristol's suggestion, which dates from as far back as 1907.

Patented Toys

Success in This Field More Difficult Than Commonly Supposed

Everybody has read stories of little inventions that have brought great wealth to their inventors. Among the examples cited in these tales are the India-rubber eraser attached to a lead pencil, the nerve-racking toy known as the cricket, the protective metal plates attached to shoe heels, etc.

Herr F. Hermann, in a recent contribution to *Die Umschau*, admits the possibility of acquiring wealth by the skillful exploitation of a little invention, but asserts his skepticism in regard to most stories of this sort. In Germany, at least, the records of the Patent Office show that few of the patents issued for little inventions live longer than two or three years, and that ninety-nine per cent of the survivors are subsequently abandoned because they are not sufficiently lucrative to pay the heavy taxes which are imposed on patented articles in Germany.

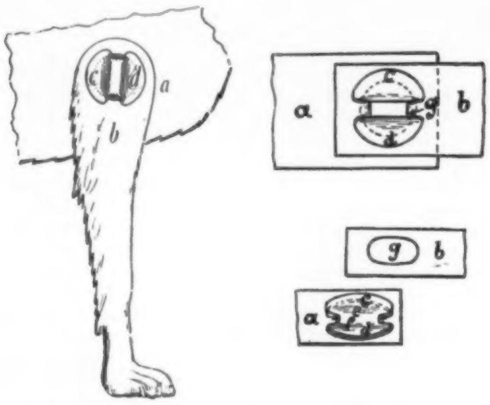


Fig. 1.—Joint for Cardboard Animal Figures.

As German patents are granted for a term of fifteen years, every patent issued since 1897 might still be in force, if it had not lapsed through non-payment of taxes or some other cause; yet of more than one hundred patents on toys issued between 1897 and 1900 only two are now in existence, and one of these concerns an article of sport, rather than a toy, in the strict sense of the word.

This article is a dumb-bell provided with a compressible and resilient handle, operated by springs, elastic bands, pads, or other devices, for the purpose of affording exercise to the hand as well as to the arm. The inventor is the celebrated athlete Emil Sandow.

The only other patent in the class of toys that was issued prior to 1900 and is still in force was granted for cardboard figures of men and animals, in which the limbs are attached to the trunk by joints of simple construction, which give the limbs the same freedom in two directions that the ball and socket joints of the hips and shoulder give, in three dimensions, to the limbs of living men and animals. The construction of the joints is illustrated in Fig. 1. Two semi-circular flaps *c d* are cut in the piece of cardboard *a*, which represents the body of the animal, in such a manner that each flap remains attached to the piece *a* along a portion of its straight edge, *e* or *f*, these straight edges being parallel to and near each other. The articulating piece *b*, which represents the limb of the figure, has a circular opening *g*, smaller than the flaps, which, however, can be passed through it by bending them. This having been done, the flaps are pressed back into their original positions, as nearly as possible. The limb can then be rotated completely around the joint, and the friction between it and the flaps holds it in any position in which it is placed.

If it is desired to restrict the movement of the limb to a part of the circle, the circular position cut out of the piece *b* to form the opening is not entirely removed, but is left attached along the line *g'* (Fig. 2). The motion is then limited by the impact of *e'* upon *g'*. Either of the articulating pieces may be provided with a cardboard handle *h*.

Cardboard figures, furnished with five of these joints, at the neck, shoulders, and hips, can be made to assume a great variety of attitudes and are deservedly popular with children (Fig. 3). Yet the inventor, George Cohn, found the task of exploitation far more difficult than that of invention. In a letter to Herr Hermann he says that the buyers of toys are always in search of novelties and the "hit" of one season may be almost unsalable a year later. Many millions of these jointed figures, most of them having five joints, have been sold.

Fig. 3.—Cardboard Monkey With Movable Head, Arms and Legs.

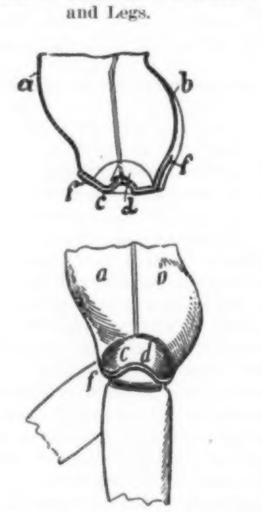


Fig. 4.—Ball and Socket Joint for Doll.

Of patents issued for toys between 1900 and 1905, more than two dozen are still in existence. Most of these surviving patents relate to dolls, toy steam engines and railways, and building blocks.

One of the oldest was granted to Heinrich Handwreck for a true ball and socket joint for dolls, the construction of which is illustrated in Fig. 4. The body of the doll is made in two parts, and the front part *a* is securely fastened to the back part *b* at the groin, by means of a stamped piece of thin material *c*,

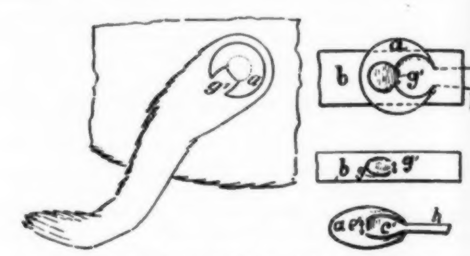


Fig. 2.—Joint With Restricted Motion.

which is pressed hot upon the parts *a* and *b* and attached to them by adhesives, applied to its edges *f f*. This connecting piece *c* is provided with depressions *d*, which form ball and socket joints with the hemispherical ends of the leg pieces. This construction gives great strength and durability to the joint and to the entire doll. In a supplementary patent the connecting piece *c* is omitted and the sockets are impressed in the edges of the parts *a* and *b*, which are folded upon each other and attached by pressure, heat, and adhesives.

Five of the patents on toys which were issued before 1905 and are still in force were taken out by the Nuremberg firm of toymakers, Carette & Company, for slide valves for toy steam engines. Yet this firm, in a letter to Herr Hermann, expresses the opinion that patents on toys are not worth the high charges imposed by the German government, because the public considers only price and external appearance, and buys cheap and worthless imitations in preference to more expensive articles of merit.

One of these older and still surviving patents is for a doll's head with movable eyes and eyelids; and another, issued to the same firm, bears the remarkable title: "A device for preventing the injurious influence of variations in temperature upon the mobility of the eyes of celluloid dolls' heads."

It is evident from the examples and the testimony cited above that the making of a successful little invention is a difficult task, which few persons are able to accomplish. All of the toys which are still manufactured under patents issued prior to 1908 were invented by professional toymakers.

The Industrial Use of Ozone*

An Oxidizing Agent of Varied Applicability

By F. Mollwo Perkin

The production of ozone by the discharge of a frictional electrical machine was originally noticed by Van Marum in 1785, but it was Schönbein in 1840 who first actually prepared it and gave it the name of "ozone," from the Greek ὄζειν, meaning smell. He also showed that it was much more active as an oxidizing agent than ordinary oxygen. As is well known, it is produced by the slow oxidation of phosphorous, and the peculiar odor of this element is really not the odor of phosphorous, but the odor of ozone, and this can be shown to be the case by adding small quantities of substances to phosphorus, which prevent its oxidation, when the odor is no longer perceptible. It also appears to be produced in small quantities by the burning of hydrocarbons. It is likewise formed in the open country, partly by evaporation, but probably most largely by the action of ultra-violet rays from the sun. This at any rate would account for its formation in the higher regions of the atmosphere. It is formed in considerable quantities when fluorine acts upon water. If a drop of water is introduced into a tube filled with fluorine, reaction immediately ensues, and the tube becomes filled with deep blue vapor. This is ozone which has a blue color when concentrated.

Ozone is also produced at the anode when acid solutions of water are electrolyzed, particularly if the electrode is a platinum tube through which cold water is passed. By this means Fischer and Massenez have obtained oxygen containing 25.27 per cent of ozone in electrolytic oxygen by electrolyzing at 0 degree. Such a process would not, however, be satisfactory on a large scale, owing to the cost of production. It is also produced by heating and suddenly cooling oxygen, and also by the action of the ultra-violet rays, produced by the mercury-vapor lamp. The only method employed commercially to prepare it is to subject oxygen to the action of the silent electric discharge, the oxygen thereby receiving electrical energy and becoming converted into ozone thus:

$$3\,O_2 + \text{energy} = 2\,O_3.$$

As the formation of ozone is an endothermic reaction it follows that it is less stable than oxygen, and is in a condition in which it will readily part with the energy originally received electrically in the form of heat, e. g. when the pure gas explodes, or as chemical energy when it acts as an oxidizing agent. The thermochemical equation accounts for its instability:

$$O_2 + O = O_3 - 32{,}400 \text{ cal.}$$

It is only within the last decade that the employment of ozone for the purification of water has been practically worked out and actually employed commercially. Various processes have been suggested and employed for the

*Reprinted from *Nature*.

sterilizing of water, and it will perhaps be as well in the first place to refer to the different forms of construction of the apparatus. All the apparatus employed depends upon some method or other of obtaining a silent electric discharge; consequently very high electrical potential is necessary. In general the silent discharge takes place between conducting plates separated by means of a dielectric. The original ozonizer of this type was the invention of W. von Siemens, and consisted of two concentric tubes, which are coated on their outside surfaces with tinfoil, the glass of the tubes acting as the dielectric. Berthelot used glass as the dielectric and a liquid as the conducting material. Modifications of both these forms are used commercially. The "Ozonair" apparatus consists of wire gauze as the conductor, separated by mica as dielectric. The ozonizer is inclosed in an iron case when the ozone is to be produced for water sterilizing or similar purposes. When it is required for the purification of the air or for ventilation it is open and the air is drawn through the apparatus and distributed by means of a fan. Fig. 1 shows a semi-inclosed type in which the grid can be entirely inclosed by completely boxing in. The electrical tension employed is about 7,000 volts.

The Siemens-Halske type which is used for water sterilizing is illustrated in Fig. 2. It consists of concentric pipes D and E placed one within the other; the inner one is of aluminium, and is connected with the leads carrying a high-tension current marked in the diagram as +, as this is the positive pole. The glass cylinder E is the other pole; it is surrounded with water which can be cir-

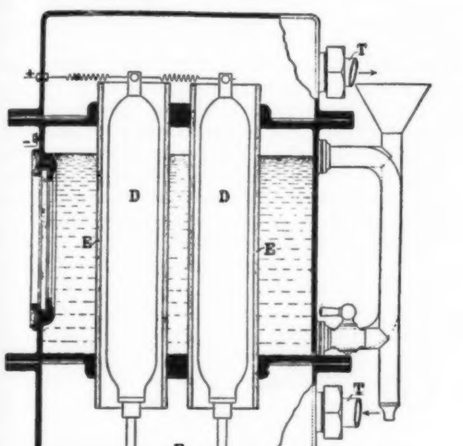


Fig. 2.—Siemens-Halske Ozonizer for Water Purification.

culated for cooling purposes, and as this is "alive" the pole receives its charge from it. The water which surrounds the glass cylinder receives its electricity from the iron-containing box, which is earthed, and consequently forms the negative pole. The annular space between D and E is where the silent discharge takes place. The complete apparatus consists of a cast iron box divided into three chambers, the lower chamber for receiving and conveying the air to the ozone tubes, an hermetically sealed middle compartment into which the ozone tubes are inserted by means of a stuffing-box-gland, and an

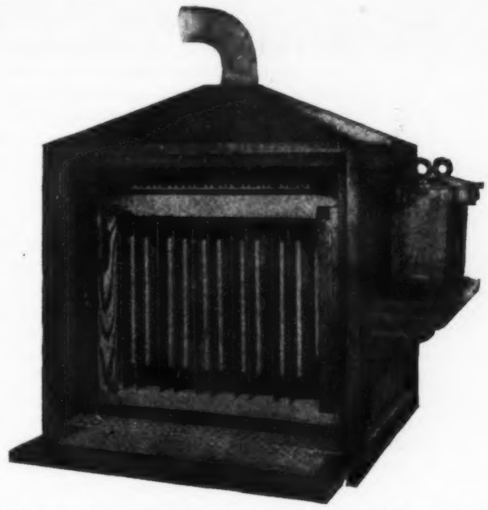


Fig. 1.—The "Ozonair," for Purifying the Air of Public Halls and Buildings.

upper compartment for collecting the ozonized air. An alternating current at 8,000 volts is employed.

A very high tension apparatus is the Abraham Marmier, in which a potential of 40,000 volts is employed. It is made up of a number of hollow cylindrical electrodes, which are insulated by means of glass and contained in a box. For cooling purposes water is circulated through the electrodes.

The Otto ozonizer consists of a series of transverse plates, so arranged that a dielectric plate is placed between the electrodes. The air is drawn or blown between the plates, the silent discharge passing between the spaces of the plates and thus ozonizing the air. Fig. 3 shows diagrammatically the manner in which the air passes through the apparatus. An alternating current at 6,500 volts is employed. In another form of the Otto ozonizer there is a metal chamber, the walls of which make one electrode. Within this chamber a number of sheet steel rings are mounted on an axle, the edges of the rings being sharpened. When in operation this bunch of rings is rotated and forms the other electrode. No dielectric is used. Air is blown through the box, the rotation of the central electrode causing thorough mixing. If an arc is struck it is immediately extinguished as the electrode rotates, because each of the rings has a groove cut in it. The tension of the current employed is about 25,000 volts.

The providing of a pure water supply to our towns, cities, and villages is of the very highest importance. In some cases where the water comes from sources in which contamination of the supply is out of question, such as from mountain lakes or from deep springs, no special purification is necessary. In other cases, however, where the source of water admits of, or even invites, contamination, purification in some way or other is a *sine qua non*. The method chiefly employed is mechanical filtration. Chemical methods, such as treatment with oxidizing agents, can only be carried out on a small scale. The sand filtration method is partly bacterial and partly one of filtration. The surface of the sand becomes coated with a slimy deposit which is partly of bacterial formation; consequently the water first passes through the bacterial layer which exerts a beneficial effect in destroying harmful bacteria, and also makes a much finer filter than can be produced by the more or less coarse-grained sand, and then it percolates through the sand. Sometimes, however, owing to floods and special contamination, the filter-bed breaks down, and then it may be a very serious matter for the populace. Therefore where there is a possibility of water at any time being contaminated, purification by some other means is advisable.

In the Ozonair process the ozonization of water takes place in three stages, that is to say, the same water comes into contact with ozone three times. In the first place, the water is atomized in presence of ozonized air, and the minutely divided particles of water then fall upon the upper part of a pile of glass spheres, or other scrubbing arrangement, packed in a tower. As the water percolates down it meets an ascending stream of ozonized air. At the bottom of the tower it falls into a tank through which ozonized air is blown by means of nozzles beneath the surface of the water in the tank. The tank is in the shape of an inverted cone, and a syphon is carried to the bottom of the cone for carrying off the water. Owing to this arrangement, all the water is equally acted upon before being carried away. The syphon discharges the water on to steps, so that it cascades down into the storage tank. As it cascades the water comes into contact with the atmosphere, and the excess of ozone is given up. Fig. 4, which is self-explanatory, shows diagrammatically the arrangement of the plant. Should the ozonizer get out of order or cease to work, the water supply is automatically cut off.

The Siemens-Halske system is largely employed on the Continent, the largest plant erected being at St. Petersburg. In this plant the method of sterilization is slightly different from that previously employed. The water is conveyed into an emulsifying tower by means of special injectors, the ozonized air being used to force the water into the bottom of the tower. The water and ozone therefore enter together, and consequently very complete emulsifying takes place. The water flows over from the top of the tower, and is cascaded down to the reservoir. In this particular case the water of the Neva is the source

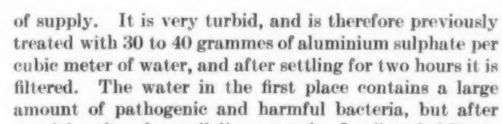


Fig. 3.—Diagram of Otto Ozonizer.

of supply. It is very turbid, and is therefore previously treated with 30 to 40 grammes of aluminium sulphate per cubic meter of water, and after settling for two hours it is filtered. The water in the first place contains a large amount of pathogenic and harmful bacteria, but after ozonizing these have all disappeared. In all probability a considerable number are removed by the precipitation treatment, because when water is softened by means of lime or other precipitant it is always found to contain less bacteria than before treatment. But, of course, precipitation could not entirely be depended upon for sterilizing purposes. On the other hand, ozone can be depended upon to sterilize. The St. Petersburg plant is capable of dealing with 2,000 cubic meters of water per hour. There are three 150-horse-power steam engines for motive power, one, however, being always held in reserve. The whole output of the engines is not required for working the ozonizers, as the power is also used to operate the pumping and filtering plant and all the other necessary mechanical appliances. The ozonizers are worked with a three-phase alternating current at 7,000 volts and 500 periods.

Other places on the Continent where ozone is used for sterilizing the public water supply are Paderborn, Wiesbaden, Paris, Hermannstadt, Florence, Nice, Chartres, Villefranche, Rovigo, and Chemnitz. Two new ozone plants are being installed in Paris with a daily output of 45,000 cubic meters of water.

In the United States ozone is employed at Philadelphia. The water ozonized is from the River Schuylkill in West Philadelphia. This is extremely impure, and is said to

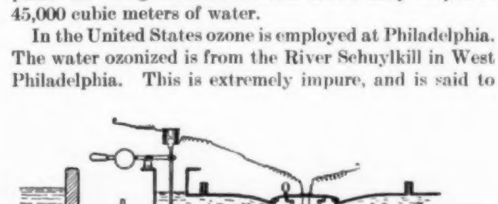


Fig. 5.—Apparatus for Sterilizing Water by Ultra-Violet Light.

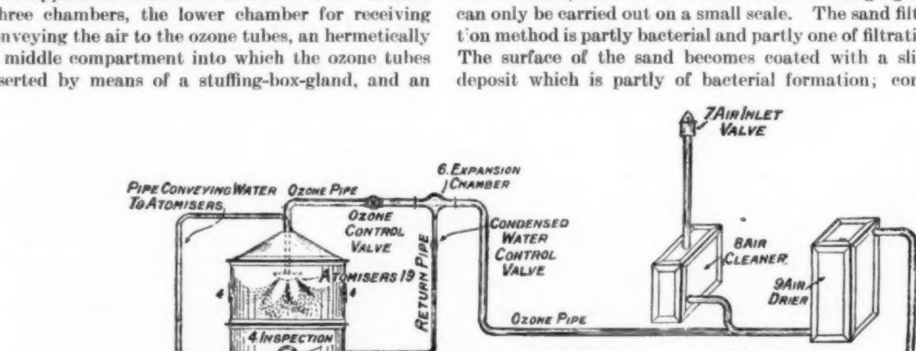


Fig. 4.—Diagram of Ozonair Plant for Water Sterilization.

contain 2,500,000 bacteria per cubic centimeter. After treatment the number is reduced to 25 per cubic centimeter. The *Bacillus coli* which previously abounds is completely destroyed. The color of the water is improved and its offensive odor removed.

It is obvious from the foregoing that the employment of ozone for sterilizing water is now being carried out on a very considerable commercial scale, and it is found not only efficient but also very cheap. In this country (England) to sterilize 1,000 gallons of water the cost is from one halfpenny to one penny (1 cent to 2 cents) according to the size of the plant and the cost of the electrical power. In connection with the sterilization of water, it should be mentioned that it is an easy matter by means of gasoline motors to use ozone for sterilizing water during campaigns. Indeed, during the Russo-Japanese war a portable plant supplied by Messrs. Siemens and Halske was employed with great success. The apparatus consists of two small wagons, each of which is hauled by one horse. The small dynamo and all the pumping appliances, etc., are worked by means of a gasoline motor.

Ozone apparatus has also been devised for fitting on to the ordinary water main, the ozonizer only functioning when the water tap is turned on. The water passes through a special form of injector which causes a thorough admixture with the ozone. At the moment the water is drawn off it smells of ozone, but within a few minutes the odor has gone off, and the water is fit for drinking purposes. This form of ozonizer is very useful in hospitals and other public institutions.

A new method for production of ozone in large quantities has just been described by E. H. Archibald and H. von Wartenberg. Dilute sulphuric acid is electrolyzed with a direct and alternating current. The alternating current acts as a depolarizer, and the production of ozone is 300 times greater than with a direct current only. The maximum yield was obtained with an alternating current of 6 amperes and a continuous current of 0.25 to 1 ampere. Increase in the frequency of the alternating current increases the ozone yield.

Before leaving the question of water sterilization another method which is now being employed should be mentioned. It has been found that the ultra-violet rays are very efficient for sterilizing water. The rays are produced by a mercury-vapor arc inclosed in a quartz tube. Under the influence of the rays from a mercury-vapor lamp of silica with a current of 3 amperes at 220 volt *B. coli* are killed in

1 second	at a distance of		10	centimeters
4 seconds	"	"	20	"
15 "	"	"	40	"
30 "	"	"	60	"

Where water is to be sterilized it is necessary for it to be clear, because the ultra-violet rays are very rapidly absorbed. This is particularly the case if water contains colloids. The various classes of microbes are not equally sensitive; e. g., conditions which kill *staphylococcus* in five seconds will kill cholera in from twenty to sixty seconds.

Lamps of glass are useless, because the glass absorbs a great portion of the rays. Fig. 5 shows the construction of the apparatus for water sterilization brought out by Cooper-Hewitt Westinghouse Company. The apparatus is made to sterilize different units, the largest size being capable of dealing with 600 cubic meters in twenty-four hours. The diagram practically explains itself. *L* is the lamp, which is inclosed in a box with rock-crystal windows. The water to be sterilized, which must, if not clear, be previously filtered, passes in at *R*, and by means of baffling is caused to pass three times past the rays in the sterilizer *E*. In case of the lamp going out, there is a valve *S*, electromagnetically operated, which opens, and immediately prevents the water from flowing through the sterilizing chamber. This apparatus is used at Rouen, where the water for the suburb Maromme-les-Rouen is sterilized by three units. Several other cities in France are also experimenting with ultra-violet sterilization. For small scale work the ultra-violet sterilization is very well adapted, but ozone is better for large scale operations. The great advantage of both of these processes is that nothing is added to the water. With the ultra-violet rays it is a question of killing by means of light. With ozone the sole product remaining at the end of the operation is oxygen.

Ozone, or ozonized air, is most useful for ventilating purposes. The air of crowded rooms is dangerous to health from the large percentage of noxious organic impurities, many of them bacterial, which it contains. Ordinary ventilation, while minimizing these, does not entirely do away with them. If, however, the fresh air driven into the room for ventilation be previously ozonized, the organic impurities become oxidized. Ozonized air is, as a matter of fact, very largely employed in the ventilation of theaters and other large public buildings. Complaint is continually made as to the evil effect of the atmosphere of the House of Commons upon the members of Parliament, and this, in spite of strenuous efforts on the part of ventilation engineers. Probably the atmosphere would be greatly improved if the ventilating shaft which supplies fresh air to the House had an ozonizing apparatus placed in it. At the Turin Exhibition the beneficial effects of ozone were forcibly brought before the notice of the writer. An ozone plant is now being employed in the ventilation of the Tube Railways with beneficial results.

Ozone is used in the manufacture of vanillin from isoeugenol. It has also been found advantageous in brewing. Weak yeast appears to be strengthened by ozone and to act more vigorously if the air of the fermenting house is kept fresh with ozonized air. Ozone is used for bleaching oils and fats, the results being very striking. It is also used for blowing oils such as linseed oil. The bleaching effect of ozone has been found useful in laundries and for bleaching delicate fabrics. Flour is bleached by means of ozone. In this case, however, as a rule the apparatus is arranged to give at the same time small quantities of oxides of nitrogen. The flour is not only bleached but also sterilized. Unbleached rye meal which contained 2,400 micro-organisms per gramme before treatment contained 1,600 per gramme after treatment. In another case, unbleached wheat flour contained 5[illegible] organisms before treatment, and 170 after treatment.

The maturing effect of ozone on wines and spirits is remarkable. Spirit which requires years for aging is matured in a remarkably short time by emulsifying with ozone. The use of ozone in tobacco factories to aid the maturing has also been suggested.

Parasitic Adaptation*

A Case of Degenerative Evolution from Higher to Lower Forms

By B. M. Underhill, V. M. D.

Living things upon cursory observation appear to be at peace with one another, and little may be noticed that is disturbing to the harmony between the organism and its environment. We find, however, on more careful examination, that there are sources of constant interference operating to destroy organisms, to restrict their multiplication, or even bring about their total extinction. Animals prey one upon another, and drive each other from a favorable to an unfavorable habitat, while changes in the earth's surface and in climatic conditions make localities inhospitable to certain animal groups which previously had thrived amid favorable surroundings. There is, in fact, a perpetual "struggle for existence" which may lead to the seeking of shelter from the conflict in a changed and often degenerate mode of life to which the animal becomes adaptively modified. Thus, through such influences, we may have a terrestrial animal driven to an arboreal or even an aquatic or semi-aquatic existence. A defenseless little member of the Insectivora burrows and becomes subterranean, while another finds protection in the nocturnal habit, others seek the shelter of caves or rock crevices, and we often find creatures, usually somewhat degenerate, in places which seem to us quite unfavorable to the support of even the higher invertebrates. While in such cases the animal continues to lead a free and independent, often solitary existence, a communion of life's interests may be established between two animal organisms which causes us to surmise that this association is founded upon some mutual advantage in the strife. To such association the general term symbiosis has been applied, and each of the organisms concerned is referred to as a symbiont. Though there is by no means a uniformity in the use of these terms by zoologists, it will serve here to subdivide symbiosis into the three categories, mutualism, commensalism and parasitism. In the first there is a reciprocal advantage derived from the union; in the second but one symbiont is benefitted though the other suffers no harm, while in the third division we have one receiving an advantage to the detriment of the animal which it invades. There is, however, no sharp line of demarcation between these three states of living together, and it may be difficult to determine in some cases whether one or both symbionts are benefitted by the union, or whether one is or is not injured by it.

One of the more obvious examples of mutualism is the case of the hermit crab and the sea anemone. This crab selects a shell, often that of the whelk, for its habitation, from the opening of which it projects only its head and claws. On the surface of the shell may often be found a sea anemone fastened near the opening, with its mouth and tentacles in the vicinity of the crab's head. The anemone in this position not only in a measure serves to conceal the hermit crab from its enemies, but the creature that would prey upon the crab must first reckon with the dangerous, stinging threads with which the tentacles of the anemone are armed. The anemone is benefitted, in its turn, by being carried about by the crab and aided in this way in obtaining its food.

Such associations, however, are not always of mutual advantage, and may be more in the nature of an invasion of one animal upon or within the body of another, the invading animal alone deriving benefit, while the animal upon which the association is forced, though not benefitting, may in no way suffer from it. A familiar form of this living together (commensalism) is the little crab so commonly found in the shell of the oyster. The oyster is not harmed by its presence, but the crab is benefitted by the protection which the shell affords. Another more curious example of such association is afforded among the vertebrates by the species of *Remora*, or suck fishes, which have the first dorsal fin modified into a sucking disk on top of the head. By means of this disk it attaches itself to a shark or other large fish, and is thus carried about, detaching itself only to secure food. Its benefit from such association is in being carried to new feeding grounds without efforts of its own, and in the shelter from its enemies which the body of the larger fish may afford. The host, on the other hand, cannot be benefitted, nor does it seem to suffer by the presence of its uninvited guest.

Whether this relationship between different species is of reciprocal advantage, or of benefit to but one, neither of the symbionts lives upon or at the expense of its co-symbiont, and neither has entirely renounced its independence. In true parasitism the invading animal lives at the expense of its host. We have many familiar examples of this form of symbiosis, and the conditions that seem always to attend it, such as the degeneration, slight or extreme, of the parasite, are familiar to all observers of animal life. It is the common habit of many animals, however, to prey upon the bodies of other animals, and we should distinguish, so far as we may, between those which are predatory in habit and those which are parasitic. The former are free, and exercise their powers of sense and cunning in snaring or chasing their prey, while the latter live on or in the bodies of their victims, often burrowing into and consuming the body substance, leading a lazy, beggarly existence in which all the faculties of special sense and prowess, so highly developed in predatory animals, become degenerate through the atrophy of disuse.

Parasitism is found throughout the range of animal life from the unicellular to the vertebrate, and, though we may not make a sharp distinction between predaceous and parasitic animals, in view of the degrading influence of the parasitic habit, we should clearly define the difference between the simplicity of degeneration and the simplicity of primitiveness. In the development of a primitively simple animal the young stages are more simple than in the adult, and it has had only simple ancestors. In the degenerate animal, on the other hand, the ancestors are often more complex, and the young stages of a higher grade than the stage of the adult, and the adoption of any mode of life which withdraws from the activities and shirks in the pursuit of food seems to bring about this condition of degradation. Of this we have a remarkable example outside of the realm of parasitism in the Tunicata. These aberrant animals in the stage of the free-swimming larva have a chordal axis which in nearly all of the different species becomes entirely lost before they reach maturity. After passing the "tadpole" stage there follows an extreme specialization to the fixed habit which most tunicates retain throughout their adult life, becoming what are known as "sea squirts," mere, attached, plant-like sacks, emitting a jet of water when disturbed, and from which all chordate features have been entirely lost. The degenerative changes which a parasite undergoes concern mostly the nervous system, the organs of locomotion, and those of nutrition, the nervous system becoming reduced to the most indispensable portion, while of the sense-organs nothing may be left except those of touch. The locomotor apparatus may become modified into claws or hoods for clasping the hairs of the host, or may more or less completely disappear and be replaced by such organs of fixation as sucking-disks. As the contents of the alimentary canal or tissue fluids of the host upon which the parasite is nourished need scarcely any digestion, the digestive organs become simplified or may be quite lost, and the absorbtion of nutriment take place entirely through the body integument, as in the case of some of the worms which infest

* Reproduced from *The Proceedings of the Delaware County Institute of Science.*

the intestines of man and other animals. The degree of decadence will depend upon the degree of dependence upon the host. In this latter respect the parasitism may be optional, as in the case of the mosquito, which may live upon the juices of plants, but which prefers a meal of warm blood, or it may be obligate, depending upon the body of another for its means of subsistence, though such obligate parasites as the biting flies, fleas, and certain household bugs, may also live free and only occasionally visit their hosts, this form being accompanied by little modification. In the event of the parasite becoming progressively degraded into one which not only seeks its host for food, but has become dependent upon it for both its nutrition and place of abode, all of the above mentioned phenomena of adaptation become more conspicuous. We are furnished an interesting example of such a transformation in the so-called sheep tick (*Melophagus ovinus*), not a true tick, however, but a fly, which, originally an occasional visitor, has, like the louse, taken permanent abode upon its host. No longer taking the aerial flight of its discarded free life, this fly has become wingless, and, furthermore, is enabled to pass its entire life cycle upon the body of the host animal by a remarkable method of reproduction involving the retention of the eggs in the oviducts until development has passed through the larval stage. It is not until ready to pass into the stage of the pupa that these are extruded, when the pupal case is attached to the individual wool fibers. From this case the young insect, on becoming sufficiently developed, makes its escape and proceeds to feed and grow, thus rounding out a complete parasitic cycle.

While the easy life of the parasite tends to degeneration, the perpetuation of the species becomes more precarious, and the organs of reproduction undergo a strong development. If a host animal dies, most of its parasites, especially those existing in the interior of its body, die with it and, were it not that the eggs find lodgment in a new host, the parasitic species would in a short time become extinct. The transmission of but few of these eggs is successfully accomplished, and in compensation they must be produced in enormous numbers, well protected from the many elements of destruction which they encounter. The mode of reproduction is one of the principal factors determining the conditions of parasitism, and, while the above modifications pertain more to those dwelling permanently within the bodies of their hosts, we have in the *Œstridæ*, among the dipterous insects, a cycle involving internal parasitism during the larval stage; a familiar example being the common horse botfly (*Gastrophilus equi*). In the warmest hours of the day, during the late summer months, the female of this fly hovers about the head, shoulders and fore legs of the horse, then darts down, deposits its egg upon a hair, and at once flies away, soon to return and repeat the process, until hundreds of eggs may be found on the same horse. In about fourteen to twenty days these eggs are hatched, a vivacious larva emerging, which, crawling on the skin, causes a slight irritation, impelling the horse to lick, the larva reaching the mouth in this way, or possibly still within the egg. Being carried to the stomach with the food, it becomes fixed upon the mucous membrane by means of two buccal hooks, and, with head plunged deep into an alveolus, subsists upon the inflammatory products of the small wound which it makes. After a sojourn here of about ten months, the larva becomes detached and is passed along with the intestinal contents, to be finally expelled from the body of its host. It then becomes concealed in the ground, and is soon inclosed in its pupal case, from which, after the elapse of about thirty to forty days, it emerges as the perfect insect. It is plain that a very small percentage of the eggs deposited can reach the horse's mouth, and that having got thus far, many of the larvæ must be destroyed or pass entirely through the intestinal tube without having succeeded in becoming fixed to the mucous lining. For this nature seems to have compensated in the large number of eggs deposited by the persistent female.

While in some cases the complete life cycle of a parasite requires but one host, more often, for reasons above stated, two successive and generally specifically different hosts are required. A rather complicated example of the latter phenomenon is the life history of the common liver fluke (*Fasciola hepatica*), one of the flat worms infesting in its adult state the livers of herbivora. This parasite is interesting in that it must necessarily alternate between a mammal, usually the sheep, and an aquatic snail, in completing its cycle. The adult form occurring in the sheep's liver is leaf-like, about three-quarters of an inch long, and has two prominent suckers, one on the under side of the body and one surrounding the mouth. The eggs, of which each individual fluke is capable of producing in the neighborhood of 100,000, pass into the bile duct of the sheep, from which they enter the alimentary canal and reach the exterior with the excrement. Here, if the proper conditions of moisture and temperature necessary for further development are present, the embryo makes its escape. At this stage it is active, ciliated, free-swimming, and not unlike certain infusoria—the period of the miracidium and a very critical one in its history. It cannot survive in this condition for more than twelve to eighteen hours, therefore if during this time it does not come in contact with a snail it is doomed to perish. Finding its molluscan host (*Limnæa humulis*) the larva, by means of its conical rostrum and a rotary motion of its body, forces its way into the tissue, most frequently that surrounding the lungs. Here it becomes more oval in shape, the cilia disappear, and it enters the stage of the sporocyst, which very early may by simple division produce two individuals. Within the body of the sporocyst there appear from five to eight cellular masses which, becoming transformed into energetically moving bodies, finally rupture the maternal sac and issue forth as so many radiæ—these, on obtaining their liberty, passing through the tissues of the snail and becoming fixed in another organ, usually the liver. Within the body of the redia there are formed daughter rediæ, which again produce other rediæ, until a large number of these forms become lodged in the tissues of the snail. Finally the redia gives rise to still another form, the cercariæ, which is somewhat heart-shaped and possesses a long and flexible tail. The cercaria leaves the snail host and proceeds to swim energetically about, eventually fixing itself upon an aquatic plant, blade of grass, or other object within or near the water. The tail now disappears, while from certain cells expelled from the body there is formed a cyst in which the cercaria becomes inclosed, the cyst being attached to the blade of grass or other object upon which the cercaria has lodged. If now a herbivorous animal, in grazing over the wet land or in drinking the water in which it may float, swallows this cyst, the cyst wall is broken down in the stomach by the action of the gastric juices, the young fluke is set free, and, reaching the duodenum, finds its way to the liver by way of the bile duct. Here it fixes itself and grows to maturity and the egg-laying stage from which we started upon this peculiar cycle.

It will be noted that this life history is a very hazardous one, and that its completion must depend upon the co-operation of numerous favorable conditions; the eggs must reach the exterior amid surroundings favorable to their hatching. If hatched, the larva must escape its many aquatic enemies, and within a few hours find its suitable snail host. Providing the snail is not eaten by a duck, or does not otherwise perish during this phase of the cycle, it issues from its host as the free-swimming cercaria, when it is again liable to fall prey to various small aquatic animals. Escaping this and becoming incysted, the chance of any herbivorous animal coming along and swallowing it is very small. The relation of the enormous number of eggs and the number of individuals which one egg may produce, to the survival of the species amid conditions fraught with such dangers, seems quite evident.

So varied are the conditions that surround the propagation of parasites that few of them, of course, can be reviewed here. In general it may be said that their prodigious fecundity and the great vital resistance with which most of them are endowed, enables species to survive and perpetuate their kind amid varied destroying influences which otherwise would bring about their extermination. The *Tænia* inhabiting the intestines of man affords us another example of extreme parasitism accompanied by this remarkable development of the reproductive function. Here is a creature so altered to its degenerate existence that it has become devoid of mouth or intestine, the body consisting of a head from which are given off segments which remain united until there is formed a band-shaped colony of from 1,200 to 1,300, streaming back from its attachment for a length of from fifteen to twenty feet or more. After about the six hundredth, each segment is a mature and complete sexual individual, which later, as it is pushed on by new segments formed at the head, becomes filled with fecundated eggs. By the successive detachment of these "ripe" segments (proglottids) and their passage from the body of the host, it has been estimated that the unarmed *Tænia* of man (*Tænia saginata*) might throw off in a year as many as 150,000,000 of eggs. These may escape from the uterus of the proglottid, or one to several attached proglottids containing the eggs may become scattered upon the ground. In either case, through their contamination of fodder or drinking water, they may, if so fortunate, reach the stomach of cattle where the egg shells are digested away and the contained embryos set free. At this stage (proscolex) the embryo possesses six minute hooks, arranged in three pairs, by which it bores its way through the intestinal wall and wanders to a muscle, where it comes to rest; or, if it finds its way into a blood vessel, it may be carried with the blood to any organ of the body. Finding its place of lodgment, it loses its hooks, increases in size, and the head of the future tapeworm is then developed in an invagination of the cyst wall with which the embryo has become surrounded. During this development the cyst pushes the tissues aside to make room for itself, and, through the irritation produced, an outer cyst wall is formed, made up of the connective tissue of the host, the complete organism or bladder worm (*Cysticercus bovis*) thus formed having consumed a period of time from the release of the embryo variously estimated at from seven to eighteen weeks. If the host animal is slaughtered before the *Cysticercus* becomes calcified, which stage of degeneration will be reached in about six to eight months from the invasion, and the incompletely cooked meat be used by man for food, the cyst, upon arriving in the stomach, is digested away, the head and neck (scolex) alone remaining uninjured. The scolex then passing into the small intestine, fastens to the wall by means of the suckers with which its head is provided, obtains nourishment by absorbtion of nutrient intestinal fluids of its host through the general surface of its body, and proceeds to give rise to segments by transverse division directly back of the head and neck; thus developing the strobila, or colony of sexually mature proglottids, similar to that of the ancestor from which the cycle started in the intestines of a previous human host. Here, then, is an animal well showing the degree of degeneration which may be reached in extreme parasitism; there are no organs of locomotion, no organs of special sense, no organs of digestion, no organs of respiration, and none of circulation. The body consists of a long band of connected segments, each bisexually complete, and in itself a sort of independent reproductive animal, the entire energy of the organism concentrated upon the function of reproduction, that the perpetuation of the species may be insured amid the perils with which this process is beset.

In many forms permanently parasitic there is an early period of development in which organs of locomotion are distinctly present, but, as the animal matures, these fail to develop or become lost. If we assume that this gradual loss of organs, change of structure, and protective transmission of the embryo to an intermediate host is due to the parasitic life, it seems reasonable to conclude that all of the parasitic groups have been derived from free-living forms, and that, as parasitism became a more fixed habit, such structural changes were in the course of time brought about as would make this mode of life obligatory. Furthermore, by comparison of the different parasitic groups, we find all gradations, from scarcely modified forms which are optional or occasional visitors to their hosts, to those of intense parasitic habit, which show the greatest change of structure and most complicated life history.

Dr. Henri Martin's Discoveries at La Quina

In the Scientific American Supplement of February 10th, mention was made of the very recent discoveries at La Quina. Interesting data concerning these have now come to hand. We present herewith a brief abstract of an article dealing with the subject in a late number of *Le Monde Illustre*.

The skeleton uncovered at La Quina by Dr. Martin late in the summer of 1911 bids fair to be as interesting as the one at Chapelle-aux-Saints.

Dr. Martin, who is a grandson of the celebrated French historian of that name, is himself a distinguished scientist, and a former president of Société Préhistorique. About seven years ago his attention was called by a colleague to the richness of the deposits of human fossils at La Quina on the banks of the Voultron. He journeyed thither and confirmed the information by personal observation, with the results that he has been digging there ever since. His labors have enabled him to reconstruct the daily life of these paleolithic people with considerable exactness. Their homes were not in the valley but in the caves at the bottom of the cliffs on its banks. However they were able to scramble up and down with considerable ease because their great toes were opposable to the other digits of the foot just as the thumb is to the fingers.

The mounds of refuse in the valley contain weapons and implements of various sorts as well as bones of animals, some of such enormous size that they must have been killed close at hand. Besides the arrow heads, etc., of chipped flint, certain calcareous stones were found, rounded and pierced, suggesting use in bolas or slings. A pierced bison tooth was probably a pendant.

Dr. Martin's enthusiasm is shown by the circumstance that when the skull referred to came to light last summer he spent the whole of the ensuing night in cutting out a block of earth of size sufficient to ensue the complete skeleton. This block was then transported to his laboratory where the delicate and laborious task of freeing it from its matrix could be better accomplished.

According to the journal quoted above, La Quina is an especially favorable spot for scientific excavations because, owing to a combination of geologic circumstances, the various strata are very precisely defined. It adds, "from an inspection of the layer of earth in which the skeleton was found, it is obvious that it cannot be of a period later than the lowest *mousterien*, and may possibly be still earlier. If this last hypothesis be verified Dr. Martin's discovery will be of unprecedented importance, for we shall have a specimen of a human creature coming next to the *pithecanthropus* and forming a link between that and the lowest *mousterien* type."

Reviews of New Books

Die Mühle des Lebens. Physikalisch-chemische Grundlagen der Lebensvorgänge (The Mill of Life. The Physico-chemical Basis of Life-Processes.) By Wilhelm Ostwald. Leipzig: Theod. Thomas. 1911. Price, 1 Mark.

It is a matter for no small self-congratulation to the reading public that a man of Ostwald's caliber should be devoting a very considerable portion of his efforts to popular expositions of some of the most advanced concepts of modern science. In his book "Die Energie," published in 1908, he says: "It has, for a number of years, been the main effort of my scientific and practical endeavors, in investigation, in teaching and in writing, to prepare the soil for the future development of the application of the energy principles to sociology." We may take it that the little book before us represents one of the links in the chain which Ostwald is forging. There is probably no other man living better qualified in every way to perform the task.

The title of the book, "The Mill of Life," perhaps requires a little explanation. Since the days of Liebig it has been understood that the material substratum of which all living matter is built up is continually undergoing a cycle of changes. Plants build up reduced carbon compounds from the carbon dioxide in the air, under the influence of sunlight. Animals build up their substance by feeding upon plants, either directly or indirectly (the latter in the case of carnivorous animals). The waste products of animals are again assimilated by plants, thus closing the cycle.

Now, as Ostwald remarks, it might at first sight appear as if the conditions were thus given for an almost unlimited increase of the living world. "For," says he, "the more plants there are, the more animals can be sustained; and again, the more animals there are, the more waste material is there for plants to grow on;" but there is evidently something wrong with this argument, and it is very easy to see where the error creeps in: we have left out of the question the dependence of plants upon light. In fact, this is where the analogy with the mill appears. The circulation of matter through the cycle spoken of above may be likened to the turning wheel of a mill; the wheel is essential for the working of the mill, and its rotation furnishes the possibility of a continuous function for an unlimited period of time, but something more is needed; the real driving agent is the water that falls from a higher to a lower level. In the same way the animal and vegetable kingdoms in nature furnish means whereby the life processes can be maintained, but the ultimate agency on which they all depend is the stream of light energy sent to us from the sun, and as this stream is limited in amount, just so there is a certain limit to the amount of life which can develop on the surface of the earth. And furthermore, just as the mill wheel performs a cyclic motion in returning and passing through its initial position, ready to proceed on the next revolution, so the circulation of matter in the living world represents a cycle of changes which can be repeated over and over again. On the other hand, the course of the water through the mill is no such cyclic change, but a change one-directional in time. The water falls from the higher to a lower level, and there is nothing in the working of the mill to return the water to its original level. In the same way, the circulation of matter in the living world is a cyclic process which ever returns to the point from which it started, and thus goes on indefinitely. On the other hand, the light which we receive from the sun represents a one-directional change, a change which can never be made good: Slowly, the sun must be cooling down, unless, indeed, there are other agencies at work of which we are not aware.

These are some of the main facts which Ostwald has illuminated with his masterly treatment, in terms which render the situation thoroughly clear and intelligible to the layman having little or no technical knowledge. It seems almost superfluous to say any words of commendation or praise in reviewing a book of this kind by such an author. Nevertheless, it may not be amiss to say that anyone who takes an interest in the matter treated, which every intelligent person ought to do, cannot afford to let this book pass by unread.—A. J. L.

Exercise and Health. By Dr. Woods Hutchinson. New York: Outing Publishing Company, 1911. 16mo.; 156 pp. Price, 70 cents net.

Dr. Woods Hutchinson needs no introduction to the American public. His pungent but good-natured style of writing will be recognized by readers the country over. In impressing upon the average man the benefits of judicious exercise, he calls attention to the fact that half the weight of a normal man lies in his muscular system, and that the heart itself is a hollow muscle amenable to the laws of exercise and growth. His explanation of the fatigue poisons and their actions is made by the use of such homely analogies and philosophical quips as are calculated to make the reader first chuckle and then think—and it is in its stimulating qualities that the chief strength of the little book lies.

Sehen Riechen Schmecken. Biologie D. Sinnesorgane II. Von Dr. H. Dekker. Stuttgart: Kosmos, Gesellschaft der Naturfreunde, Franckh'sche Verlagshandlung.

Contemporary Chemistry. A Survey of the Present State, Methods, and Tendencies of Chemical Science. By E. E. Fournier d'Albe. New York: D. Van Nostrand Company, 1911. 180 pp.

The review of a book such as the one before us is a most pleasurable task. There is a romance about the development of contemporary science which, if once realized, seems to surpass almost anything within the history of mankind; and the writer of this book is not only thoroughly well equipped with the knowledge necessary, but has also a full appreciation and grasp of this romantic aspect of the present situation. Moreover, he commands a style and form of diction which enables him to transmit to his readers something of his own spirit and point of view. It is not very often that a writer thoroughly well informed in matters of science has also the gift of presenting them to the world at large in a form which is at the same time attractive and true to the facts. It is, therefore, with particular pleasure that one welcomes a work of this kind which displays these qualities to an unusual extent.

The first chapter is devoted to a brief introduction, entitled "The Situation," in which the author indicates the position of chemistry among the other branches of science and its relation especially to the most modern developments of physical science—for there is a very marked tendency for this development to take on a form which would seem to indicate that we are approaching the time when the last dividing line between chemistry and physics will have become obliterated.

The second chapter, headed "A Retrospect," gives a very brief review of the past history of chemistry. Such a review naturally contains little or nothing that is new, but the chapter is very well composed and naturally fits into the scheme of the book at this point.

The third chapter is devoted to the subject of "The Molecule," and very briefly goes into some of the physicist's ideas of the molecule, as derived from the kinetic theory of gases.

The fourth chapter, "States of Aggregation," gives a summary of the phase rule, Le Chatelier's theory and related matters. As regards Le Chatelier's theorem, the reviewer might be allowed a slight digression here, to refer to the fact that within the last few months we have become accustomed to seeing this theorem quoted and discussed from various points of view, some particular interest having been recently aroused by the attempt to apply it to biological and similar problems. While such attempts are very interesting and suggestive, considerable caution must be exercised in accepting them, for, in the first place, the principle itself is not beyond criticism, as has been shown plainly enough by a writer in a recent number of the *Zeischrift für physikalische Chemie;* and, moreover, there is a tendency to apply it somewhat loosely without first considering whether all the conditions which warrant its application are fulfilled. It is also to be remembered that the principle is, after all, only a qualitative expression of facts which can be expressed quantitatively in terms of the second law of thermodynamics.

Chapter V is devoted to the phenomena of optical activity of various kinds in its relation to chemistry. Chapter VI treats of the theory of solutions. Chapter VII is headed "Osmotic Pressure." One of the interesting points here brought out is the fact that the surface of separation of a solution and its vapor acts as a semi-permeable membrane transmitting solvent molecules but arresting solute molecules.

Chapter VIII, dealing with "Affinity," gives, among other things, an attempt to explain chemical forces in terms of electrical attraction, and discusses in this connection the size of the atom as computed on this basis. Chapter XI deals with "Chemical Analysis." The last section is a brief note on the micro-balance, an instrument capable of detecting differences of weight down to four-millionths of a milligramme. It is interesting to note that this small quantity of matter which can thus be detected by this balance still represents an aggregate of one million million atoms.

Chapter XVII is devoted to the atomic theory and includes a discussion of the periodic law. As an example of the almost incredible inertia which frequently opposes the introduction of a new idea into science, it is interesting to quote here a little passage relating to Newlands' first paper on the "Law of Octaves," as he called it, that is to say, practically Mendeleeff's periodic law: "When Newlands read this paper before the Chemical Society, one of the members present facetiously asked him whether he had tried the result of arranging the elements in alphabetical order!"

The closing chapter, XIX, is headed "Chemistry of the Future." Among other things one point which is brought out is the analogy between certain problems of chemistry and more particularly of radio-activity on the one hand, and of biology on the other. We refer to the fact, which is familiar enough, that the amount of a transformation product in a chain of radio-active changes is determined by two factors, first, the rate of formation of the particular product considered, and, secondly, its rate of disintegration or decay. In this respect the amount of the substance considered resembles closely a population whose number is maintained at a certain value by the balance struck between the birth rate and the death rate. The author says: "There must, in fact, be equilibrium between the birth rate and death rate of atoms. Such equilibrium is not unknown in the organic world. A naturalist may calculate with some certainty the relative numbers of given species in a pond whose average temperature and whose soil are known. These numbers are constant or but slightly fluctuating, the surplus of one species being counterbalanced by the excessive growth of a species hostile to it." This aspect of the subject is one of peculiar interest and one which promises to bring interesting developments in the future, although hitherto it has been dealt with merely as a side issue, more or less for illustrative purposes. As a matter of fact, there seems to be room here for some extended work in the application of principles familiar to us from physical chemistry, to certain phenomena dealt with by the vital statistician, the biologist, the biometrician, and others whose work is concerned with one form or other of manifestations of individual and social life.

In addition to the subjects taken up in the chapters considered somewhat in detail above, a number of other topics are discussed, of which the following is a partial list:

Optical Activity in Its Relation to Chemistry; the Theory of Solutions; Valency; Electro-Chemistry; Theory of Crystals; Organic, that is to say, Carbo-Chemistry; Chemistry and Life; the Chemistry of the Metals; Industrial Chemistry.

The little book here reviewed covers a wide field in a small compass, and there can be no pretense of depth of detail in treatment. On page 143 we observe that the name Zsigmondy is misspelled. The Latin dedication seems to us something of an anachronism. It appears to be the function of a reviewer to point out these little things; for the rest, the book seems to be remarkably free from blemishes.

The volume forms most stimulating reading and, as already stated, not only is the substance clear and accurate, but the form is also attractive and scholarly. The book will take a high place among works of this character.—A. J. L.

Neue Energetik. By Leo Gilbert. Dresden: Carl Reissner, 1912. 229 pp.

The title of this book might lead a trusting reviewer to expect some account of the very interesting development of energetics as guided for instance by the genius of Ostwald and Helm. But the reviewer finds himself forced to confess to a feeling of considerable disappointment. No doubt a book of this kind must be reviewed with a great deal of circumspection and with a full allowance for the difficulty which is always associated with the discussion of the philosophical aspect of science. To quote the author's own words, "This work will require from many a reader detailed and searching study before he is able to 'work himself into it.' Since the book brings a radical recasting of our customary modes of thought, down to the smallest detail, no headway can be made without searchingly thinking over the problems from their very foundation. In short, the reader must become re-schooled."

It cannot be denied that the writer of the book has a right to expect such careful study from his reader, especially if such reader takes upon himself the responsibility of offering criticism. It is therefore with some hesitation that one presents such criticism; for will not the author reply to any criticism offered with the objection that the critic has not given that careful study to his book which the author expressly stated was necessary? However—surely the least that can be expected, if the writer of the book wishes to insist on such careful study, is that he should be reasonably careful in the choice of his words, so as to place no unnecessary obstacles in the way of the reader's understanding of the text. Let us note whether the author has fulfilled this requirement. Surely a good rule to follow is to avoid using with a new meaning terms which have become established in regular use with some exact and well-defined significance, unless for some reason or other such a step is absolutely necessary, in which case it should be made perfectly clear what the new meaning is and wherein it differs from the old. Furthermore, in such case surely the writer should be thoroughly consistent in the new use of the word. Now, we read on page xiii, "Matter is that which we ordinarily call density." On page 23 we read, "Mass, that is, density." Again, if we read the opening sentence on the last paragraph of page 13, we seem to gain the impression that what the writer really means by density in this paragraph is the property of offering resistance to our touch, for he says, "Matter is distinguished from empty space in that it offers a resistance to our hand. . . . Matter is, therefore, that which we, in other words, call density." But we read on: "Carbon, for instance, is more than one hundred times denser than liquid hydrogen." The last sentence seems to imply that here, for once, the author uses the word *density* in its usual meaning, namely, mass per unit volume. Now, we ask if the author means by density what we term mass, why does he not say mass? If he means something new, why does he not clearly state what he means? And if he uses the word in the old sense, then some of his statements seem unwarranted. The truth seems to be that he uses the word in a variety of different ways, none of them particularly well defined, and leaves the mind of the reader in a state which reminds one of Mark Twain's story of his meeting with Artemus Ward.

This confusion by the author in the use of the term *density* is here cited merely as an example. The whole language of the book shows the same diffuseness and intangibility. It seems, therefore, that the author has not given the reader that help in the grasping of the subject treated, which can reasonably be expected, namely, clarity of expression; and it seems somewhat doubtful whether he is entitled to the right of receiving that careful study which he requests, for he is really asking more from his reader than he is giving him.

Many other criticisms suggest themselves on reading the book. It must suffice to point out one or two further examples. The text of the book opens with a number of definitions. On inspection these display a feature which may be of certain psychological interest as giving an insight into the type of mind possessed by the author, but which seems to deprive them of any other claim for serious consideration. The author says: "We distinguish between *movement* (*Bewegung*) that is, *acceleration*, and *motion* (*Wegung*) that is to say, *free velocity*." The criticism which here naturally suggests itself is that if the concept of *movement* is fully identified with the old term *acceleration*, then there is no object whatever in introducing a new term; if, on the other hand, the new concept is not fully described by the old term, then the author has failed to make clear what he means by his expression. The same criticism applies to the paragraph on the next page where the author says that "internal energy" is identical with "potential energy," and "external" with "kinetic." If this identity exists, then why introduce new terms? Apparently the author takes great pleasure in calling old things by new names, at least it seems difficult to explain sentences like the ones just quoted on any other basis. The reviewer must confess that he has not spent that extended effort on an attempt to fully assimilate all that the author has to say, which the reader of the book is asked to do. But from the few examples quoted it will appear that there is some justification for refraining from such detailed study. It has been said that a clear thinker should also be a clear speaker or writer. It appears to the reviewer that the author is not a clear writer. One might be willing to give him the benefit of the doubt as to whether he is a clear thinker, but one thing is certain, that although clear thinking may be possible with confused language, it is certainly impossible by such language to convey one's meaning to others; and nothing can be gained by adding to the difficulties with which the reader is supposed to be confronted by the nature of the subject, further, artificial difficulties necessitated merely by the task of becoming accustomed to a new terminology, in which a variety of old concepts are introduced under new names, seemingly for the mere purpose of pleasing a whim of the author.

The Life of Charles Dickens. By John Forster. Collected, arranged, and annotated by B. W. Matz. New York: The Baker & Taylor Company, 1911. Two volumes. 8vo.; 500 facsimiles and other illustrations. Price, $8 net.

Forster's Life of Dickens was first published in 1871, and was at once recognized as being one of the most powerful biographies ever written, and which has even been compared with Boswell's Johnson. To see this book so worthily presented is indeed a treat. The annotator has spared no pains in making this book one which will appeal to all Dickens lovers. It appears at a psychological moment, just about the time of the great Dickens centenary of 1912.

Perhaps the most interesting feature of the book is the reproduction of the original covers of the paper parts in which his works of fiction were originally published. These are inserted and printed on stock of the original color. The number of houses, hotels, etc., at which Dickens stopped for any length of time is very large, and the collection in this book is truly remarkable. A cursory examination of it shows that Dickens "moved" not less than forty-three times in his lifetime, and he always improved his manner of living. Another interesting feature of the book is the reproduction of play bills, for Dickens was a remarkable amateur actor. There are also many reproductions of his manuscripts. The whole world has been searched for portraits. The book is beautifully printed and bound. It is an ornament to any library, no matter how small. It gives in detail the life of a man who is in the very front rank of those who set their seal on the wonderful nineteenth century. Charles Dickens did more than any other man to relieve grievous conditions in England, and his influence was felt in other countries, notably our own, for he did much to correct certain national crudities which undoubtedly existed at the time he wrote his "American Notes."

TABLE OF CONTENTS

PAGE
Water Supply for the West Australian Gold Fields.—By L. E. Shapcott.—2 illustrations.... 257
The Geology of Dam Trenches.—By Herbert Lapworth.—1 illustration.... 258
A Curve which Trisects Any Angle.—By L. L. Thurstone.—1 illustration.... 259
Gold Lacquer for Metals.... 259
A City of Poured Houses.—6 illustrations.... 260
The Divine Kings of the Shilluk.—5 illustrations.... 261
Monoplane Failures.—1 illustration.... 262
The Balanced Aquarium.—By Raymond C. Osburn.—8 illustrations.... 263
Fundamentals.—I.—By Onward Bates, M. W.S.E.... 266
Engineering Feats and Cheaper Food Supplies.... 267
Patented Toys.—4 illustrations.... 268
The Industrial Use of Ozone.—By F. Mollwo Perkin.—5 illustrations.... 268
Parasitic Adaptation.—By B. M. Underhill, V.M.D.... 270
Dr. Henri Martin's Discoveries at La Quina.... 271
Review of New Books.... 272

h he requests,
is reader than

themselves on
e to point out
he text of the
finitions. On
e which may
t as giving an
ssessed by the
e them of any
ration. The
veen *movement*
and *motion*
elocity." The
gests itself is
ully identified
n there is no
new term; if,
t is not fully
e author has
by his expres-
to the para-
e author says
ith "potential
etic." If this
e new terms?
t pleasure in
least it seems
the ones just
eviewer must
xtended effort
all that the
of the book
ew examples
ome justifica-
ed study. It
should also
ppears to the
clear writer.
he benefit of
lear thinker,
though clear
sed language,
language to
and nothing
ficulties with
onfronted by
er, artificial
the task of
minology, in
e introduced
nere purpose

KENS. By
anged, and
New York:
any, 1911.
similes and
8 net.

published in
being one of
written, and
h Boswell's
y presented
s spared no
will appeal
t a psycho-
of the great

ure of the
ginal covers
works of
hose are in-
iginal color.
, at which
ime is very
is truly re-
shows that
-three times
proved his
feature of
y bills, for
tor. There
manuscripts.
r portraits.
ound. It is
how small.
ho is in the
seal on the
es Dickens
ve grievous
ce was felt
for he did
ities which
wrote his

NTS

PAGE
a Gold
llustra-
.... 257
Herbert
.... 258
-By L.
.... 259
.... 259
ons... 260
ustra-
...... 261
.... 262
ond C.
.... 263
s, M.
...... 266
l Sup-
...... 267
.... 268
Hollwo
...... 268
derhill,
.... 270
Quinn. 271
.... 272